Lloyd's Register

Rules and Regulations for the Classification of Ships, July 2013

Notice No. 4

Effective Date of Latest Amendments:

See page 1

Issue date: October 2013

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RULES AND REGULATIONS FOR THE CLASSIFICATION OF SHIPS, *July 2013*

Notice No. 4

This Notice contains amendments within the following Sections of the *Rules and Regulations for the Classification of Ships, July 2013*. The amendments are effective on the dates shown:

Part	***Chapter***	***Section***	***Effective date***
1	2	2	1 September 2013
1	3	2, 5	1 September 2013
3	4	8	1 September 2013
3	9	7	1 September 2013
3	14	Whole Chapter	1 September 2013

It will be noted that the amendments also include corrigenda, which are effective from the date of this Notice.

The *Rules and Regulations for the Classification of Ships, July 2013* are to be read in conjunction with this Notice No. 4. The status of the Rules is now:

Rules for Ships	Effective date:	July 2013
Notice No. 1	Effective date:	1 July 2013
Notice No. 2	Effective date:	1 August 2013 & Corrigenda
Notice No. 3	Effective date:	1 September 2013 & 1 January 2014
Notice No. 4	Effective date:	1 September 2013

Part 1, Chapter 2

Classification Regulations

Effective date 1 September 2013

■ *Section 2*
Character of classification and class notations

2.1 Definitions

(*Part only shown*)

Table 2.2.2 Special features notations (*see continuation*)

Special features notation	Description	*See also*
BLS	Bow Loading System. Assigned to tankers equipped with bow loading arrangements to facilitate the transfer of cargo oil from offshore loading terminals	Pt 7, Ch 6,1.2.1
BoxMax	Where a container ship has an approved onboard container lashing program which is installed and maintained in accordance with the requirements of the Rules, the special features notation **BoxMax** may be assigned on application from Owners. In conjunction with the notation **BoxMax**, the following supplementary characters may be assigned and are to be shown consecutively in brackets; **V** may be assigned where, in addition to the requirements for **BoxMax**, the onboard lashing program is capable of performing calculations specific to defined sea areas, and the weather-dependent factors for these areas have been supplied by LR; **W** may be assigned where, in addition to the requirements for **BoxMax(V)**, the onboard lashing program is capable of performing calculations specific to defined sea areas and seasons, and the weather-dependent factors for these areas and seasons have been supplied by LR	Pt 3, Ch 4 and Ch 14

2.8 Descriptive notes

2.8.4 Where an approved loading instrument is provided as an Owner's requirement, a descriptive note **LI** may be entered in column 6 of the *Register Book, see also* 2.3.16.

2.8.5 Where container securing arrangements are designed and constructed in accordance with Pt 3, Ch 14, but where the Initial and Periodical Survey requirements for loose fittings are not requested, the ship will be eligible to be assigned the descriptive note **CSA** (container securing arrangement) and for an entry to be made in column 6 of the *Register Book*.

Existing paragraph 2.8.5 *has been renumbered* 2.8.6.

Part 1, Chapter 3

Periodical Survey Regulations

Effective date 1 September 2013

■ *Section 2*
Annual Surveys – Hull and machinery requirements

2.2 Annual Surveys

2.2.40 ~~Where a special features notation 'certified container securing arrangements' is assigned, the Surveyor is to examine the securing arrangements so far as necessary and practicable in order to be satisfied as to their general condition.~~ The Surveyor is to examine the fixed cargo securing fittings as far as necessary and practicable in order to be satisfied as to their general condition, *see* Pt 3, Ch 14,10.

2.2.41 Where the special features notation **CCSA** (certified container securing arrangements) is assigned, the Surveyor is to examine the securing arrangements including loose fittings so far as necessary and practicable in order to be satisfied as to their general condition, *see* Pt 3, Ch 14,10.

2.2.42 The Surveyor is to confirm that, for container ships which have the special features notation **BoxMax**, the onboard lashing program, together with its operation manual, is available on board, *see* Pt 3, Ch 4,8. The operation of the program is to be verified in accordance with LR's certification procedure.

Existing paragraph 2.2.41 *has been renumbered* 2.2.43.

■ *Section 5*
Special Survey – General – Hull requirements

5.3 Examination and testing

5.3.19 Where ~~a~~ the special features notation **CCSA** (certified container securing arrangements) ~~'(certified container securing arrangements)'~~ is assigned, the Surveyor is to be satisfied as to the efficient condition of:

(a) Cell guide structure including the connections between vertical cell guides and cross ties.
(b) Cell guide entry devices.
(c) Portable frameworks or other forms of structural restraints.
(d) Fittings attached to the ship structure, with special attention to any signs of leakage in way of tanks or deck and shell plating.
(e) End connecting pieces for lashings, twist locks and other loose fittings, which are to be examined and verified with the Register.
(f) All lashings, rods, wire ropes, and chains, together with turn buckles and other tightening devices, which are to be examined and verified with the Register.
(g) Lashing wire ropes, which are to be renewed where more than five per cent of the wires are broken, worn or corroded in any length of 10 diameters of the wire rope.
(h) Chains, which are to be renewed where worn or damaged.

Where renewals are required, the new item is to be of approved type and manufacture. Where test certificates are not available, the item is to be tested in accordance with Pt 3, Ch 14,3.

Part 3, Chapter 4

Longitudinal Strength

Effective date 1 September 2013

■ *Section 8*
Loading guidance information

8.4 Onboard lashing program

8.4.1 An onboard lashing program to calculate forces acting on the container stowage arrangement may be provided, *see* Chapter 14. This may be an extension to the loading instrument covered under Ch 4,8.3. If the software to carry out lashing calculations is installed and maintained in accordance with the Rules, the ship will be eligible to be assigned the special features notation **BoxMax**, with one or more of the supplementary letters **V** and **W**.

8.4.2 To qualify for the notation **BoxMax** the following requirements must be satisfied:

(a) The onboard lashing program is to be certified in accordance with LR's *Approval of Longitudinal Strength and Stability Calculation Programs*.
(b) Where alteration to the container stowage arrangements is proposed, the onboard lashing program is to be modified accordingly and details submitted for approval.
(c) The operation of the onboard lashing program is to be verified by the Surveyors upon installation and at Annual and Periodical Surveys as required in Pt 1, Ch 3. An Operation Manual for the onboard lashing program is to be verified as being available on board.

8.4.3 The onboard lashing program may also have the capability to take account of the various sea areas through which the container ship may trade. If the software to carry out lashing calculations is installed and maintained in accordance with the Rules and includes the functionality to take account of voyage route using the methodology and factors supplied by LR, the ship will be eligible to be assigned the special features notation **BoxMax(V)**.

8.4.4 To qualify for the notation **BoxMax(V)** the following requirements must be satisfied:

(a) The requirements for **BoxMax** must be satisfied.
(b) The benefits of the notation may only be applied in sea areas for which LR has provided the factors for the ship. Elsewhere, the weather-dependent factors must be set to the values defined for unrestricted worldwide service, *see* Pt 3, Ch 14,1.5.
(c) The voyage- specific aspects of the onboard lashing program are to be verified by the Surveyors upon installation and at Annual and Periodical Surveys as required in Pt 1, Ch 3. An Operations Manual for these aspects of the onboard lashing program is to be verified as being available on board.

8.4.5 The onboard lashing program may also have the capability to take account of the various seasons during which the container ship may trade. If the software to carry out lashing calculations is installed and maintained in accordance with the Rules and includes the functionality to take account of voyage route and season using the methodology and factors supplied by LR, the ship will be eligible to be assigned the special features notation **BoxMax(V,W)**.

8.4.6 To qualify for the notation **BoxMax(V,W)** the following requirements must be satisfied:

(a) The requirements for **BoxMax(V)** must be satisfied.
(b) The benefits of the notation may only be applied in sea areas and during seasons for which LR has provided the factors for the ship. If the required sea areas and seasons are not fully covered by the factors provided by LR, the weather-dependent factors must be set to the values defined for the notation **BoxMax(V)**, if available, or for unrestricted worldwide service, *see* Pt 3, Ch 14,1.5.
(c) The voyage- and season-specific aspects of the onboard lashing program are to be verified by the Surveyors upon installation and at Annual and Periodical Surveys as required in Pt 1, Ch 3. An Operation Manual for these aspects of the onboard lashing program is to be verified as being available on board.

Part 3, Chapter 9

Special Features

Effective date 1 September 2013

~~■ *Section 7*~~

~~Freight container securing arrangements~~

~~7.1 Classification~~

~~*7.1.1* Where freight container securing arrangements are fitted and the design and construction of the system are in accordance with the requirements of Chapter 14, the ship will be eligible to be assigned the special features notation **Certified Container Securing Arrangements.**~~

Existing Sections 8 *and* 9 *have been renumbered* 7 *and* 8.

Part 3, Chapter 14

Cargo Securing Arrangements

Effective date 1 September 2013

Existing Chapter 14 *has been deleted in its entirety.*

■ Section 1
General

1.1 Application

1.1.1 All cargo ships, regardless of tonnage, except those engaged solely in the carriage of either liquid or solid bulk cargoes, are to be provided with a Cargo Securing Manual approved by the Flag Administration, as required by SOLAS 1974 (as amended). Sections 2, 4, 7 (if applicable) and 10 apply to all ships for which a Cargo Securing Manual is required. It is recommended that the container securing arrangements in the Cargo Securing Manual be designed in accordance with Sections 3, 5, 6, 8 and 9. Furthermore, it is recommended that the container securing arrangements be submitted to Lloyd's Register (hereinafter referred to as LR), for formal approval. In cases where LR is authorised to carry out the approval of the Cargo Securing Manual on behalf of a National Administration and the container securing arrangements have not been designed on the basis of the LR Rules nor received formal LR approval, the Cargo Securing Manual will be annotated accordingly, highlighting this fact. In general, Cargo Securing Manuals can be approved by LR if authorised by the National Authority.

1.1.2 Fixed fittings which are part of the container lashing equipment or which may affect the strength of the ship's hull are subject to approval on the basis of the requirements of this Chapter. Details of the connection and the supporting ship structure require approval to satisfy the design loads determined in accordance with Section 8 or the safe working load of the fixed fitting, as applicable. Drawings are to be submitted showing details of the fittings, the attachment, the local foundations and information about the intended materials and welding.

1.1.3 The requirements for container securing arrangements have been framed in relation to ISO Standard Series 1 ISO 1496-1:1990, including Amendment Nos. 1, 2 and 3, Freight Containers. For previous ISO 1496-1:1984 containers, reference should be made to the July 2008 LR Rules. Proposals to consider higher allowable forces in accordance with ISO 1496-1, including Amendment No. 4, 2006, will be specially considered. Proposals for the securing of other types of containers will be specially considered.

1.1.4 Containers are to be loaded so as not to exceed the weights and distribution within the stack according to the Cargo Securing Manual (CSM). The permissible loading patterns are to be clearly indicated on the Container Securing Arrangement Plan carried on board the ship.

1.1.5 Containers may be approved and certified using LR's *Container Certification Scheme*.

1.1.6 Where it is intended and specified that loose or fixed parts of the container securing system are used for lifting appliance purposes, e.g., pedestal sockets and fittings used for lifting of hatch covers, or twistlocks used for vertical tandem lifting, the requirements of LR's *Code for Lifting Appliances in a Marine Environment* are applicable. If no approval from lifting aspects is sought, the devices will be considered as part of a container securing arrangement only.

1.1.7 For ships having the class notation **Container Ship**, an effective breakwater is to be fitted to protect the containers against green sea impact loads. As a minimum, an effective breakwater is to extend above the mid-height of the outermost containers that are to be considered as protected. For other ships which are equipped for the carriage of containers on deck, protection of the cargo is recommended by the provision of a breakwater.

1.1.8 Forward of 0,75*L*, it is recommended that all door ends face aft in order to improve the performance of the container walls to withstand green sea loads.

1.1.9 Improper ship handling related to course and speed or threshold phenomena like parametric rolling can create adverse forces acting on the ship and the cargo which are in excess of the forces determined on the basis of Section 8. It is the responsibility of the Master to apply good seamanship in order to mitigate excessive ship motions to reduce forces acting on the cargo stowage arrangements.

1.2 Classification notations and descriptive notes

1.2.1 Ships with container securing arrangements which are designed and constructed in accordance with this Chapter will be eligible to be assigned the special features notation **CCSA** (certified container securing arrangements). In addition to the fixed fittings, the Initial and Periodical Survey requirements of Section 10 for all loose fittings are applicable. Where loose container securing fittings are supplied for part container stowage only, the special features notation will be suitably modified.

1.2.2 Ships with container securing arrangements which are designed and constructed in accordance with this Chapter, but where the Initial and Periodical Survey requirements for loose fittings in Section 10 are not requested, will be eligible to be assigned the descriptive note **CSA** (container securing arrangement) and for an entry to be made in column 6 of the *Register Book*.

1.2.3 The advantage of having an onboard lashing program to calculate forces acting on the stowage arrangement is highlighted. It is recommended that all ships carrying containers on a regular basis be equipped with such a tool. This may be an extension to the loading instrument covered under Ch 4,8.3. It is recommended that the program be approved by LR. If the program to carry out lashing calculations is approved by LR and installed and maintained in accordance with the requirements of this Chapter, the ship will be eligible to be assigned the special features notation **BoxMax**.

1.2.4 It is a prerequisite for assignment of the special features notation **BoxMax** that the container securing arrangements in the Cargo Securing Manual are designed in accordance with this Chapter and submitted to Lloyd's Register for formal approval.

1.2.5 The container securing arrangements of a container ship may take into account specific voyage routes and seasons, provided the ship is eligible for the special features notation **BoxMax**, *see* 1.2.3, the onboard lashing program is capable of performing calculations specific to defined sea areas and seasons and the weather-dependent factors for these areas and seasons have been supplied by LR. In this case, if the weather-dependent factors have been supplied by LR for specific sea areas, the ship will be eligible to be assigned the special features notation **BoxMax(V)**. If the factors have been supplied by LR for specific sea areas and seasons, the ship will be eligible to be assigned the special features notation **BoxMax(V,W)**. *See* Ch 4,8.4.

1.3 Plans and information required

1.3.1 For all fixed cargo securing arrangements, except container securing arrangements, the following information and plans are to be submitted:

(a) Details of certification including safe working load (SWL) of fixed cargo securing fittings.
(b) Plans of structure in way of fixed cargo securing fittings.
(c) Direction of loads imposed on the ship's fixed cargo securing fittings.
(d) A general arrangement of fixed cargo securing fittings.

1.3.2 For container securing arrangements, the following plans and information are to be submitted:

(a) General arrangement plan showing the disposition and design weights of the containers.
(b) Details of materials, design, scantlings of cell guides structure, lashing bridges, pedestals, and other container securing arrangements, where fitted.
(c) Details of certification, including safe working load (SWL), of fixed and loose container securing fittings.
(d) Plans of structure in way of fixed container securing fittings and arrangements.
(e) Design values of the following ship parameters for the container load departure and arrival conditions:
    (i) Moulded draught (T_c)
    (ii) Transverse metacentric height (*GM*).
(f) Design wind speed (V_W).
(g) The lashing calculations in the Cargo Securing Manual are to be based on two design *GM* values. The lower design value is to be taken as 2,5 per cent of the breadth *B*, and the upper design value is to be taken as 7,5 per cent of *B*. In addition to these two design *GM* values, actual *GM* values of the ship in the container loaded condition from the approved trim and stability booklet are to be included when the actual design *GM* values are outside the above range.

1.3.3 Where containers of types other than ISO containers are to be incorporated in the stowage arrangement, the Cargo Securing Manual is to indicate clearly the locations where these containers are stowed. The manual is also to indicate the container weights and required securing arrangements for stacks composed entirely of ISO Standard containers.

1.4 Securing systems

1.4.1 Containers are to be secured by one, or a combination, of the following systems:

- Corner locking devices.
- Rod, wire or chain lashings.
- Buttresses, shores or equivalent structural restraint.
- Cell guides.

Alternative systems will be considered on the basis of their suitability for the intended purpose.

1.4.2 Dunnage is not to be used in association with approved container securing systems except where forming part of an approved line load stowage, *see* 5.5.

1.5 Symbols and definitions

1.5.1 The following definitions are applicable to this Chapter, except where otherwise stated:

a = breadth of the container, in metres (for longitudinally stowed containers)
b = length of the container, in metres (for longitudinally stowed containers)
c_i = height of container *i*, in metres
d_i = flange thickness of container securing device (e.g., twistlock) below container *i*, in metres
a_0 = acceleration parameter

$$= f_{HS}\,(1{,}58 - 0{,}47C_b)\left(\frac{2{,}4}{\sqrt{L}} + \frac{34}{L} - \frac{600}{L^2}\right)$$

a_{surge} = longitudinal acceleration due to surge, in m/s^2
= $0{,}275a_0$ g
a_{sway} = transverse acceleration due to sway, in m/s^2
= $0{,}55a_0$ g
a_{heave} = vertical acceleration due to heave, in m/s^2
= a_0 g
a_{roll} = roll acceleration at the centre of motion of the vessel, in rad/s^2

$$= 0{,}69\ \frac{\phi}{T_r^2}$$

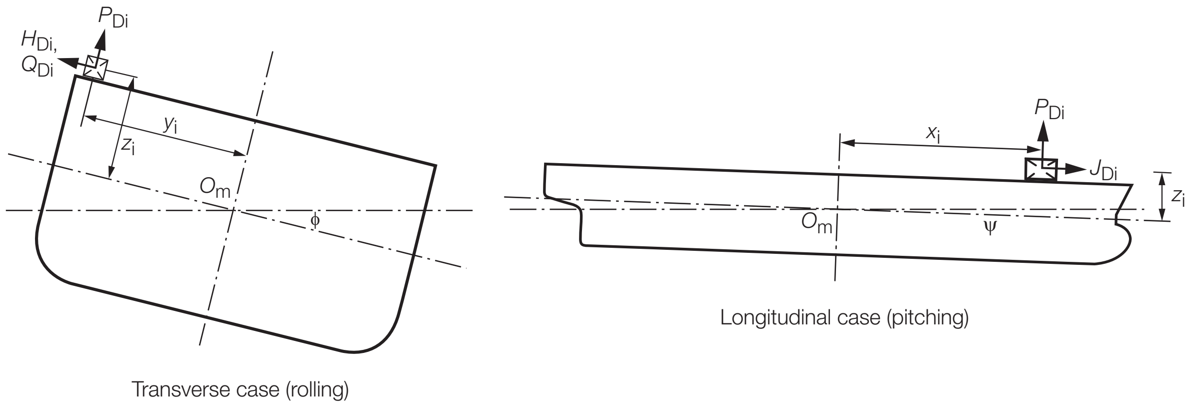
a_{pitch} = acceleration due to pitch, in rad/s^2

$$0{,}69\left(1 + \frac{0{,}98}{\sqrt{L}}\right)\frac{\Psi}{T_p^2}$$

T_p = period of pitch of the ship, in seconds, to be taken as specified in Table 14.8.1

T_r = period of roll of the ship, in seconds, to be taken as specified in Table 14.8.1
ϕ = maximum single amplitude of roll, in degrees, to be taken as specified in Table 14.8.1
Ψ = maximum single amplitude of pitch, in degrees, to be taken as specified in Table 14.8.1
e = base of natural logarithms
= 2,7183
f_{ap} = hull form coefficient
for Motion Case MC1:
= $1{,}2R_A^{0{,}3}$ for $R_A > 1{,}0$
= 1,2 for $R_A \leq 1{,}0$
for all other Motion Cases:
= 1,0
R_A = area ratio factor for combined stern and bow shape, defined in Pt 4, Ch 2,2.4. For the purpose of container stowage calculation, R_A is to be taken as 1,5 if this value is not available
f_{BK} = bilge keel coefficient
= 1,2 for ships without bilge keels
= 1,0 for ships with bilge keels
f_{Hs} = weather-dependent factor for acceleration
= 1,0 for unrestricted worldwide service
f_{HsP} = weather-dependent factor for pitch
= 1,0 for unrestricted worldwide service
f_{HsR} = weather-dependent factor for roll
= 1,0 for unrestricted worldwide service
f_{HsW} = weather-dependent factor for whipping acceleration
= 1,0 for unrestricted worldwide service
C_{p1} = hull whipping factor
= $1 + f_{MC}\, f_{wh}\, f_{HsW}$
f_{MC} = Motion Case coefficient
= $1{,}0f_{wl}$ for MC1
= 0 for MC2
= $0{,}5f_{wl}$ for MC3
= $0{,}25f_{wl}$ for MC4
= $0{,}5f_{wl}$ for MC5
= 0 for MC6
f_{wh} = whipping coefficient
= 0,55 for $x_c/L \leq 0{,}25$
= 0,20 at $x_c/L = 0{,}5$
= 0,45 for $x_c/L \geq 0{,}75$
intermediate values are to be obtained by linear interpolation

f_{wl} = length-dependent factor for whipping
= 0 for $L \leq 250$ m
= 1,0 for $L \geq 350$ m
intermediate values are to be obtained by linear interpolation
g = acceleration due to gravity and is to be taken as 9,81 m/s^2
x_c = longitudinal centre of gravity of a container forward of the AP, in metres
z_c = vertical centre of gravity of a container above the keel, in metres
x_i = longitudinal coordinate of the centre of container *i*, in metres, from O_m measured positive forwards in ship coordinate system, *see* Fig. 14.1.1
= $x_c - x_{om}$
y_i = transverse coordinate of the centre of container *i*, in metres, from O_m measured positive to port in ship coordinate system, *see* Fig. 14.1.1
z_i = vertical coordinate of the centre of container *i*, in metres, from O_m measured positive upwards in ship coordinate system, *see* Fig. 14.1.1
= $z_c - z_{om}$
x_{om} = longitudinal centre of motion forward of the AP. To be taken at the LCF of the ship
z_{om} = vertical centre of motion above the keel. To be taken as the greater of $2T_c/3 + KG/3$ above the keel T_c or $D/2$
A = side area of the container, in m^2
GM = transverse metacentric height of the ship, in metres
KG = vertical distance of the centre of gravity of the ship above the keel, in metres
L = Rule length, in metres, *see* Ch 1,6.1.1
C_b = block coefficient, *see* Ch 1,6.1.6
MC*n* = Motion Case *n*
LCF = longitudinal centre of flotation. To be taken as 0,48*L*
O_m = centre of motion, to be taken on the centreline at x_{om} and z_{om}, *see* Figs. 14.1.1 and 14.1.2
R = the rating, or maximum operating gross weight for which the container is certified, and is equal to the tare weight plus payload of the container, in tonnes
T_c = moulded draught in the container load condition, in metres
V_w = wind speed, in m/s. For ships with an unrestricted worldwide service area notation, a wind speed of 40 m/s is to be applied



Transverse case (rolling)

Longitudinal case (pitching)

Fig. 14.1.1 Diagrammatic representation of symbols

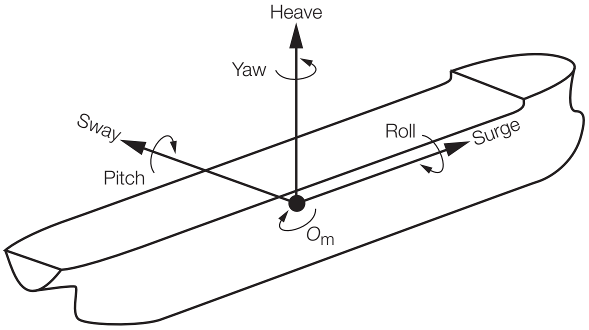


Fig. 14.1.2
Ship coordinate system and sign convention of motions

W = weight of the container and contents, in tonnes. The following minimum weights *W* are to be used:
= 2,5 tonnes for 20 ft containers
= 3,5 tonnes for 40 ft containers
= 4,0 tonnes for 45 ft containers
= 4,5 tonnes for 48 ft and 53 ft containers.

1.5.2 The sign convention for ship motions and accelerations is shown in Fig. 14.1.2. This is based on a right-handed coordinate system. The roll, pitch and yaw motions are defined positive clockwise as shown. For instance, positive sway is defined as the translation toward port and positive pitch as the rotation of the bow down and stern up.

■ *Section 2*
Fixed cargo securing fittings, materials and testing

2.1 General

2.1.1 Randomly selected samples of fixed cargo securing fittings are to be subjected to prototype testing and, upon satisfactory completion, will be granted General Approval.

2.1.2 Randomly selected samples drawn from production runs are to be subjected to production testing prior to delivery to the ship.

2.1.3 Cargo securing fittings, certified by an organisation other than LR, will be accepted where the certification scheme is to the satisfaction of LR.

2.2 Materials and design

2.2.1 Steel used for the construction of the fixed cargo securing fittings is to comply with the requirements of the *Rules for the Manufacture, Testing and Certification of Materials* (hereinafter referred to as the Rules for Materials) or with an equivalent specification acceptable to LR. Due account is to be taken of the grade and tensile strength of the hull material in way of the attachment. The chemical composition of the steel is to be such as to ensure acceptable qualities of weldability. Where necessary, tests are to be carried out to establish specific welding procedures.

2.2.2 Where securing arrangements are intended to operate at low ambient temperatures, special consideration is to be given to the specification of the steel.

2.2.3 Proposals for the use of materials other than steel will be specially considered.

2.2.4 Attention is drawn to the need for measures to be taken to prevent water accumulation in pockets or recesses that could lead to excessive corrosion.

2.3 Prototype testing

2.3.1 Prototype tests to determine the breaking or failure loads are to be carried out on at least two randomly selected samples of each item used in the securing system. The relationship between design breaking load and safe working load (SWL) is to be as indicated in Table 14.2.1.

2.3.2 The Surveyor is to be satisfied that the design and materials of the fittings are in accordance with the approved plans.

2.3.3 For acceptance, no permanent deformation (other than due to initial e~~m~~bedding of component parts) is to be induced by test loads up to the proof load given in Table 14.2.1.

2.3.4 When considering the test modes, all expected directions of operation are to be taken into account. Jigs are to be employed, where necessary, in order that satisfactory simulation is obtained.

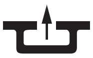
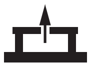
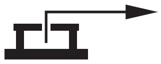
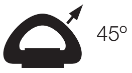
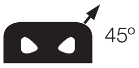
2.3.5 In the interest of standardisation of the strength of container securing fittings, safe working loads in accordance with Table 14.2.2 are recommended.

Table 14.2.1 Design breaking loads and proof loads for fixed cargo securing fittings

Minimum design breaking load		Minimum proof load	
for SWL ≤ 400 kN	for SWL > 400 kN	for SWL ≤ 400 kN	for SWL > 400 kN
2 x SWL	SWL + 400 kN	1,5 x SWL	SWL + 200 kN

NOTE
Breaking and proof loads for fixed cargo securing fittings of a material other than steel will be specially considered.

Table 14.2.2 Test loads and test modes for fixed container securing fittings

Item No.	Description	Required test modes		Recommended minimum, in kN		
				SWL	Proof load	Breaking load
1	Flush socket		Pull-out load	250	375	500
2	Pedestal socket		Pull-out load	250	375	500
			Tangential load	200	300	400
3	‘D’ ring		Tensile load	250	375	500
4	Lashing plate		Tensile load	250	375	500

NOTES
1. For items 3 and 4, where specifically designed for use with chain or steel wire rope (SWR) lashings, a lesser SWL may be considered.
2. For items 1 and 2, where multiple flush sockets or pedestal sockets are involved, test loads are to be applied simultaneously to each socket opening which can be loaded simultaneously in service.
3. For item 4, where multiple lashing points are fitted in one deck plate fitting, testing is to be similarly arranged as for Note 2.
4. Where containers with strength higher than required for ISO containers are used, consideration will be given to the required minimum loads.
5. The test modes illustrated above are diagrammatic only.

2.3.6 Where one of the required two randomly selected test samples fails before the design breaking load is reached, this can be accepted, provided that:
(a) the failure is not less than 95 per cent of the design breaking load;
(b) an additional randomly selected sample is tested satisfactorily; and
(c) the average failure load of the three randomly selected samples is equal to or greater than the design breaking load.

2.4 Production testing

2.4.1 The nature and extent of proposed production testing will be considered by LR, but the arrangements are to be at least equivalent to one of the following testing procedures:
(a) One randomly selected sample from every 50 pieces, or from each batch if fewer than 50 pieces, is to be proof loaded in accordance with Table 14.2.1.
(b) All fittings are to be loaded to the SWL of the item.

2.4.2 Consideration will be given to a reduced frequency of the mechanical production testing proposed in 2.4.1, provided that:
(a) the prototype test results indicate a breaking load at least 50 per cent greater than that required by Table 14.2.1; and
(b) a suitable non-destructive inspection procedure is agreed.

2.4.3 Permanent deformation (other than that due to initial embedding of component parts) will not be accepted unless tests are conducted in accordance with 2.4.1(a) and the SWL of the sample is 250 kN or greater. In this case, consideration may be given to acceptance of permanent deformation in the load range between SWL + 125 kN and the proof load, provided that satisfactory manual operation can be achieved after completion of tests.

2.4.4 In the event of premature failure or serious plastic deformation occurring in a test sample, a further randomly selected sample is to be selected for testing. In the event that this sample is found to be unsatisfactory, the associated batch will be rejected.

■ *Section 3*
Loose container securing fittings, materials and testing

3.1 General

3.1.1 Randomly selected samples of loose container securing fittings are to be subjected to prototype testing and, upon satisfactory completion, will be granted General Approval.

3.1.2 Randomly selected samples drawn from production runs are to be subjected to production testing prior to delivery to the ship in accordance with 3.4.

3.1.3 Loose container securing fittings, certified by an organisation other than LR, will be accepted where the certification scheme is to the satisfaction of LR.

3.1.4 In the following, the term 'fully automatic fitting' is used to describe fittings which do not require manual operation during unloading of the containers. It should be noted that usually these fittings do not mechanically secure the container in the vertical direction (perpendicular to the hatch cover) in the upright condition when subjected to pure vertical motions. Other modes of operation and novel design will be specially considered.

3.2 Materials and design

3.2.1 Steel used for loose container securing fittings is to comply with the requirements of the Rules for Materials or with an equivalent specification acceptable to LR.

3.2.2 Where loose container securing fittings are intended to operate at low ambient temperatures, special consideration is to be given to the specification of the steel.

3.2.3 Proposals for the use of materials other than steel will be specially considered.

3.2.4 Locking devices and other fittings which are inserted into the container castings on the quayside before lifting on board are to be such as to minimise the risk of them working loose under the effects of vibration and the risk of them falling out.

3.2.5 For twistlocks, bottom twistlocks, midlocks, stackers with intermediate plates and fully automatic fittings, the contact areas, for both tension and compression between the fitting and the corner castings of the containers, are to be such as not to exceed a bearing stress of 300 N/mm^2 under the safe working load of the fitting. No increase in the permissible stress level will be given due to higher strength material of the fittings. In the case where the design is such that the contact area is sloped or inclined and not parallel to the container corner casting, the effective contact area will be specially considered.

3.3 Prototype testing

3.3.1 Prototype tests are to be in accordance with 2.3.1 to 2.3.6, except that Tables 14.3.1 and 14.3.2 are to be applied in lieu of Tables 14.2.1 and 14.2.2 respectively. For vertical lashing, *see* 5.4.7(b).

3.4 Production testing

3.4.1 The nature and extent of proposed production testing will be considered by LR, but the arrangements are to be at least equivalent to one of the following testing procedures:

(a) For:
  (i) **Loose container securing fittings except chain or wire rope lashings**. One randomly selected sample from every 50 pieces, or from each batch if fewer than 50 pieces, is to be proof loaded in accordance with Table 14.3.1.
  (ii) **Chain or wire rope lashings**. One randomly selected sample from every 50 pieces, or from each batch if fewer than 50 pieces, is to be tested to breaking.

(b) All fittings, securing devices and lashings are to be proof loaded to the SWL of the item and in addition, one randomly selected sample from every batch of chain or wire rope lashings is to be tested to breaking.

3.4.2 Permanent deformation (other than that due to initial embedding of component parts) will not be accepted unless tests are conducted in accordance with 3.4.1(a)(i) and the SWL of the sample is 250 kN or greater. In this case, consideration may be given to acceptance of permanent deformation in the load range between SWL + 125 kN and the proof load, provided that satisfactory manual operation can be achieved after completion of tests.

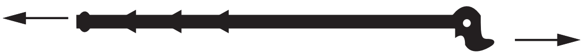
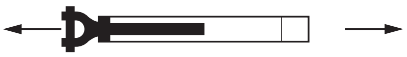
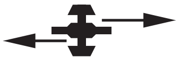
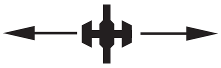
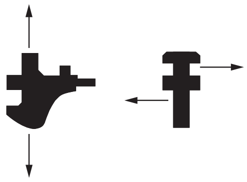
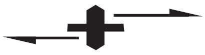
3.4.3 In the event of premature failure or serious plastic deformation occurring in a test sample, a further randomly selected sample is to be selected for testing. In the event that this sample is found to be unsatisfactory, the associated batch will be rejected.

Table 14.3.1 Design breaking loads and proof loads for loose container securing fittings

Item	Min. proof load		Min. design breaking load	
	SWL ≤ 400 kN	SWL > 400 kN	SWL ≤ 400 kN	SWL > 400 kN
Lashings Wire rope Rod: higher tensile steel Chain: mild steel higher tensile steel	1,5 x SWL	SWL + 200 kN	3 x SWL 2 x SWL 3 x SWL 2,5 x SWL	SWL + 400 kN
Other loose container securing fittings	1,5 x SWL		2 x SWL	

NOTES
1. Higher tensile steel is defined for this purpose as steel having a yield stress not less than 315 N/mm^2.
2. Breaking and proof loads for lashings of material other than steel will be considered.

Table 14.3.2 Test loads and test modes for loose container securing fittings

Item No.	Description	Required test modes	Recommended minimum, in kN		
			SWL	Proof load	Breaking load
1	Lashing rod		180	270	360
2	Lashing rod (HTS)		250	375	500
3	Lashing chain (MS)		80	–	200
4	Lashing chain (HTS)		100	–	300
5	Lashing steel wire rope		120	–	360
6	Turnbuckle	 Tensile load	250	375	500
7	Twistlock (manual, semi-automatic and fully automatic fittings)	 Shear load	200	300	400
		 Tensile load	250	375	500
8	Midlock	 Shear load	200	300	400
		Tensile load	250	375	500
9	Stacker	 Shear load	200	300	400

NOTES
1. Where containers with strength higher than required for ISO containers are used, special consideration will be given to the required minimum loads.
2. The test modes illustrated above are diagrammatic only.
3. Other fittings not covered in this Table may be specially considered, *see also* 3.5.1.
4. For assessment of a para-lash arrangement, *see* 5.4.4, where each lashing rod is modelled, the SWL is to be taken as 0,75 times the SWL of a single lashing. Where a single lashing rod is used to model both rods, the SWL is to be taken as 1,5 times the SWL of a single lashing. *See also* 9.5.2.

3.5 Function and environmental testing

3.5.1 For fittings of novel design or with special features, in addition to the prototype and production testing, a function test may be required to demonstrate that the fitting is fit for purpose. Details of the function test will be considered on an individual basis, taking into consideration the mode of operation of the fitting. In addition, LR reserves the right to require environmental tests. The actual test depends on the individual design of the fitting. The tests are to verify that environmental and ageing effects, such as corrosion, icing, debris contamination, etc., do not impinge on the safe operation of the fitting. In this case, LR reserves the right to require the submission of maintenance instructions as part of the approval procedure.

■ *Section 4*
Ship structure

4.1 General

4.1.1 The ship structure and hatch covers in way of fixed cargo securing fittings are to be strengthened as necessary, *see* 1.1.2.

4.1.2 A breakwater may be required, *see* 1.1.7.

4.2 Strength

4.2.1 The SWL of the fixed cargo securing fitting is to be used as the design load when approving the weld attachments and the support structure of the fixed cargo securing fitting.

4.2.2 For container securing arrangements, the design load when approving the weld attachment and supporting structure is to be calculated in accordance with Section 9.

4.2.3 When considering the loads, all expected directions of operation are to be taken into account.

4.2.4 Stresses induced in the weld attachments, supporting structure, cell guides, lashing bridges and other structures serving as fixed cargo securing points, determined using the design loads as defined in 4.2.1 to 4.2.3, are not to exceed the permissible values given in Table 14.4.1.

Table 14.4.1 Permissible stress values

	Permissible stress, N/mm^2
Normal stress (bending, tension, compression)	$0,67\sigma_o$
Shear stress	$0,4\sigma_o$
Combined stress	$0,86\sigma_o$
Symbols	
σ_o = specified minimum yield stress, in N/mm^2	

■ *Section 5*
Container securing arrangements for stowage on exposed decks without cell guides

5.1 General

5.1.1 Containers stowed on deck or on hatch covers are generally to be aligned in the fore and aft direction (longitudinally stowed), but alternative arrangements will be considered.

5.1.2 Containers are to be stowed so that they do not extend beyond the ship's side. Adequate support is to be provided where they overhang hatch coamings or other deck structures. The stowage arrangements are to be such as to permit safe access for personnel in the necessary working of the ship, and to provide sufficient access for operation and inspection of the securing devices.

5.1.3 Where containers are stowed on hatch covers, the covers are to be effectively restrained against sliding by approved type stoppers or equivalent. Details of the locations of stoppers relative to the supporting structure are to be submitted at an early stage.

5.1.4 Stanchions and similar structure supporting containers and securing devices, such as D-rings for lashings, are to be of adequate strength for the imposed loads and of sufficient stiffness to minimise any deflection which could lead to a reduction in the effectiveness of the securing device.

5.1.5 In the region forward of 0,75*L*, additional securing devices may be required due to green sea forces, *see* 8.2.8.

5.1.6 In general, stowage of heavy containers on top of lighter containers is to be avoided, unless validated as being satisfactory by an approved onboard lashing program or covered by the approved container securing arrangement.

5.1.7 Regarding the use of fully automatic fittings, the following requirements apply:

(a) For fittings where the locking method requires defined clearances between the corner castings and the fixed foundations, such fittings are not to be used at the lowest tier of a stack which is resting with one side on a hatch cover panel and bridging to a container stanchion. The same applies if the stack is resting on different hatch cover panels or foundations where relative deflection during ship operation can occur.

(b) If the lashing system consists of a combination of fully automatic fittings with lashing rods, only internal cross lashings are to be used. No external lashings or vertical lashings are to be applied, unless the clearance of the loose securing fitting under safe working loads is insignificantly small. Alternative arrangements will be specially considered, taking into consideration the clearances of the fittings.

5.2 Containers in one tier

5.2.1 Containers are to be secured at their lower corners by approved locking devices.

5.2.2 Alternatively, containers may be secured by lashings fitted diagonally or vertically at both ends of each container, in association with cone fittings at each container corner.

5.3 Containers in two tiers

5.3.1 Containers are to be secured at their lower corners at each tier by approved locking devices.

5.3.2 Where the calculations indicate that separation forces will not occur at any point in the stack, double stacking cones may be fitted at all internal corners of the stack and bridge fittings used to connect the tops of the rows in the transverse direction. Locking devices are to be fitted at all external corners.

5.3.3 Alternatively, containers may be secured by lashings in association with stacking cones or, where the calculations indicate that separation forces may occur, with locking devices.

5.4 Containers in more than two tiers

5.4.1 Containers are to be secured at their lower corners at each tier by approved locking devices.

5.4.2 Alternatively, containers may be secured by lashings. One or two tiers of lashings may be fitted in association with stacking cones or, where the calculations indicate that separation forces may occur, with locking devices.

5.4.3 When lashings are employed, they are usually fitted to the bottom corner casting of a container. Proposals to attach lashings to the top casting of a container will be considered. The reduced strength of the upper corner casting compared to the lower corner castings is to be taken into account.

5.4.4 Proposals to use lashings in pairs (para-lash arrangements) will be considered. Lashings in pairs are generally to be attached one to the bottom corner fitting of the upper tier and the other to the top corner fitting of the lower tier container. Suitable connections are to be provided at the lower ends. The effectiveness of paired lashings is to be taken as equal to 1,5 times that of a single lashing.

5.4.5 Where tiers are fitted at higher levels, they are to be secured by locking devices at each corner and each tier.

5.4.6 Proposals to use horizontal lashings connected to lashing bridges will be specially considered. The forces in such securing systems are to be determined by direct calculations, taking into account the following effects:

- stiffness of the container walls, the lashings and the lashing bridge; and
- the possible horizontal displacements of the containers relative to the lashing bridge due to the clearances of the hatch cover stoppers and the container securing fittings.

5.4.7 When vertical lashings are used in combination with container securing fittings, consideration is to be given to the vertical clearances between the fittings and the container corner castings:

(a) The lashing assembly is to remain elastic when subject to an elongation equating to the number of interface fittings fitted below the point where the vertical lashing is applied to the stack. In order to avoid overstressing of the rod and the turnbuckle, provision of spring or elastic elements incorporated into the turnbuckle may be advantageous. When lashing from lashing bridge level, the number of interfaces is to be counted down to the level where the lowest container is resting. The lashing rod is to be fitted to the bottom casting of the container. For container securing fittings having design clearances in accordance with ISO 3874, a nominal clearance per fitting of 10 mm is to be taken to determine the total elongation of the lashing system. For fittings having clearances in excess of 10 mm, the total elongation is to be calculated, taking into consideration the higher clearances.

(b) A prototype test is to be carried out to demonstrate that the vertical lashing has a safe working load of 150 kN when elongated up to the calculated total design clearance plus 10 per cent without plastic deformation.

(c) It is recommended that the load-bearing effect of vertical lashing arrangements be explicitly taken into account when performing lashing calculations. Where this is not done, it is acceptable to allow the permissible calculated lifting force to be increased by 150 kN in addition to the safe working load of the container securing fitting. The nominal lifting force is not to exceed 400 kN at the securing fittings below the fitting position of the vertical lashing.

5.4.8 For stowage arrangements incorporating fully automatic fittings which do not mechanically secure the container in pure vertical direction when subject to vertical motions, it is to be ensured that no separation occurs under the load cases specified in Section 8. In addition, where exposed stacks are secured with fully automatic fittings without internal cross lashings, provision is to be made to prevent buoyancy forces acting on the container which could disengage the containers. In this case, the use of effective side screens is required. Otherwise, the first tier of containers is to be secured by manual or semi-automatic twistlocks.

5.4.9 If the carriage of one or more tiers of 20 ft containers being overstowed with at least one tier of 40 ft containers, the so-called 'Russian Stow Arrangement', is desired, the following requirements apply.

(a) At the 20 ft gap the containers are to be secured by means of midlocks, whereas the fore and aft ends are to be secured by twistlocks and if necessary supplemented by lashing rods.

(b) The 40 ft overstow container is to be secured by twistlocks or if necessary with a combination of twistlocks and lashing rods. The stack is to be assessed in a two-step procedure, as follows:

    (i) For location at the 40 ft ends, the entire mixed stack is to be considered as a 40 ft stack. The weights of the 40 ft containers are to be considered in the calculations. For the tiers of 20 ft containers, the weight of one 20 ft container is to be taken as the basis for the calculation at each tier.

    (ii) For the location of the 20 ft tiers at the mid-bay position, the assessment is to be carried out as for an unlashed stack. The 40 ft overstow container does not need to be taken into consideration.

5.5 Line Load stowage

5.5.1 Where the containers are supported on bearers placed to distribute the stackweight as Line Loads, the following requirements are to be complied with:

(a) The stack is, in general, to comprise a maximum of two tiers of loaded containers.

(b) The load from the upper tier is to be transferred through the container corners. Line loading is not to be used between tiers.

(c) The load on each vertical corner post of the bottom tier, calculated in accordance with Section 9, is not to exceed one half of the Rated Load of the container.

(d) Where the calculations indicate that lifting forces may occur, locking devices are to be fitted at the container corners.

(e) The clearance below the bottom container corner casting is to be such that the stacking cone or equivalent cannot be dislodged under shear loading.

5.5.2 Where an approved Line Load stowage system is installed, the special features notation will be suitably modified.

5.6 Systems incorporating structural restraint

5.6.1 Containers may be secured by the use of a fixed structure providing permanent buttresses in association with portable frameworks. Proposals to adopt such systems will be considered on the basis of the loads developed in the structure and the corresponding stresses.

5.6.2 The framework or other devices securing the containers are to be aligned with the container corner fittings and any clearance gap is to be kept to the minimum to reduce shifting.

■ *Section 6*
Container securing arrangements for underdeck stowage without cell guides

6.1 General

6.1.1 Containers are generally to be stowed in holds in the fore and aft direction, but alternative arrangements will be considered. The securing arrangements are to be designed on the basis of the most severe distribution of loads which may arise in the container stack.

6.1.2 Containers may be secured by locking devices only or by a combination of locking devices, buttresses, shores or lashings. Containers are, in general, to be restrained at every corner at the base of the stack and at all intermediate levels.

6.1.3 Where stacks consist of one or two tiers only, consideration will be given to the omission of corner locking devices. Containers must, however, be secured by a minimum of two corner locking devices.

6.1.4 Where the calculations indicate that separation forces could occur at any particular level, twistlocks or equivalent means of securing are to be fitted at that level. Elsewhere, consideration will be given to the use of double stacking cones.

6.1.5 Where the calculations indicate that separation forces will not occur between containers at any level, consideration will be given to the use of stacking cones in lieu of locking devices throughout.

6.1.6 Buttresses are generally to be of the tension and compression type and are to be provided with means of adjustment to ensure tightness when fitted in place. Where applicable, the attachment to the ship’s structure is also to include means for vertical adjustment of the buttress to match container stacks of different heights.

6.1.7 Shores of the compression-only type may be permanently attached to the ship structure or they may be hinged or portable. When in place they are to abut the container corner fittings with minimal clearance. Means are to be provided to prevent slackening of the device.

6.1.8 Adjacent stacks of containers are to be linked in line with buttresses or shores in order to transmit lateral loads. The fittings used for these linkages are to be of adequate strength to transmit the loads imposed.

6.1.9 The ship’s structure supporting shores and buttresses is to be reinforced as necessary.

6.1.10 Proposals for alternative securing systems, including systems relying on minimal clearance between containers and hull structure, will be specially considered.

6.1.11 Attention is drawn to the safety at work aspects for fittings which require operation on top of containers, e.g., double stacking cones, bridge fittings, buttresses and shores. Where these fittings are used, fall protection is to be provided.

■ *Section 7*
Container securing arrangements for stowage using cell guides

7.1 General

7.1.1 Cell guide systems may be fitted to support containers stowed in holds or on exposed decks.

7.1.2 The cell guides are not to form an integral part of the ship’s structure. The guide system is generally to be so designed as to keep it free of the main hull stresses.

7.1.3 Cell guides are to be designed to resist loads caused by loading and unloading of the containers, to prevent shifting of the containers and to transmit the loads caused by motions of the ship into the main hull structure.

7.2 Arrangement and construction

7.2.1 Cell guides are to be of robust construction and generally fabricated from steel plate and rolled sections. They are to have sufficient vertical extent and continuity to provide efficient support to containers. Guide bars are to be effectively attached to the supporting structure to prevent tripping or distortion resulting from container loading.

7.2.2 The intersection between cell guide and cross ties is to provide adequate torsional stability.

7.2.3 Intermediate brackets are to be fitted to vertical cell guides at suitable intervals.

7.2.4 The cell guides are to give a total clearance between the container and guide bars not exceeding 25 mm in the transverse direction and 40 mm in the longitudinal direction. The deviation of the cell guide bar from its intended line is not generally to exceed 4 mm in the transverse direction and 5 mm in the longitudinal direction.

7.2.5 Athwartship cross ties are to be fitted between cell guides at a spacing determined from the loading on the guides but, generally, not more than 3,0 m apart. Wherever possible, cross ties are to be arranged in line with the corners of the containers as stowed and are to be supported against fore and aft movement at a minimum of two points across the breadth of the hold. Where, however, the maximum fore and aft deflection in the cross tie can be shown not to exceed 20 mm, one support point may be accepted.

7.2.6 Longitudinal tie bars may be required to be fitted where shown necessary by the force calculations for the structure. Where fitted, they are to comply with the requirements of 7.2.5.

7.2.7 Where, at the sides or ends of holds, the guide rails are fitted to transverse or longitudinal bulkheads, the bulkhead is to be locally reinforced to resist the additional loads.

7.2.8 If the carriage of 45 ft Euro containers complying with EU Directive 96/53 is specified to be carried in 45 ft cell guides, attention is to be paid to the arrangement of the corner castings, *see* Fig. 14.7.1. The guide bars need to be increased in order to ensure that a minimum design overlap, *a*, of 20 mm is achieved, taking into account the design clearances and tolerances defined in 7.2.4. Consideration is to be given to the torsional loads being applied to the guide bars.

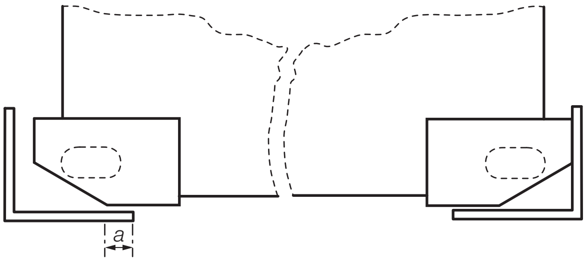


Fig. 14.7.1 45 ft euro container in cell guides

7.3 Carriage of 20 ft containers in 40 ft cell guides in holds

7.3.1 Where the cell guides are arranged for the carriage of 40 ft containers, provision may be made for the installation of temporary intermediate cell guides for 20 ft containers. The permanent structure is to be designed such that it is suitable for either loading pattern.

7.3.2 Alternatively, permanent means for the support of 20 ft containers at the mid-length of a cell arranged for 40 ft containers will be considered. Such means may include the following:

(a) A pillar (inboard) and vertical rest bar (on the longitudinal bulkhead) against which the container stack may rest. The pillar is to be supported laterally by the deck structure over and is to be sufficiently stiff to control lateral deflection of the container stacks.

(b) Guide bars supported transversely by slim structure within the gap between containers and with longitudinal ties as necessary.

Details of proposals will be individually considered, taking into account the loads on the support structure and the resulting deflections.

7.3.3 Where it is desired to stow 20 ft containers without external support at the mid-bay location with or without 40 ft overstow, so-called ‘mixed stowage’ arrangements meeting the following requirements are applicable:

(a) Maximum homogeneous container weights for 20 ft containers stowed in cell guides with no 40 ft container overstowed can be derived from Tables 14.7.1 and 14.7.2, depending on the transverse acceleration and the number of tiers in the stack.

(b) Maximum homogeneous container weights for 20 ft containers stowed in cell guides with at least one 40 ft container overstowed can be derived from Table 14.7.3, depending on the transverse acceleration and the number of tiers in the stack.

(c) Tables 14.7.1 to 14.7.3 have been derived on the basis of all containers in a stack having the same homogeneous weight. Where it is intended to carry non-homogeneous mixed stowage stacks, containers heavier than specified in Tables 14.7.1 to 14.7.3 can be loaded in the lower tiers provided that the total stack weight derived from the Tables is not exceeded. Furthermore, no container having a weight in excess of the maximum weight stated in the Tables is to be stowed on top of a lighter container. However, the total accumulated stack weight derived from the above mentioned Tables may be increased by loading the lowest container in the stack up to its maximum rated weight.

(d) Means are to be provided to prevent transverse sliding of the bottom of the stacks of 20 ft containers at the mid-bay position. This is to be in the form of permanently attached chocks at the inner bottom or equivalent. The design clearance is to be the same as for the cell guides and in accordance with 7.2.4.

(e) Stacking cones are to be fitted at each corner between tiers of the 20 ft containers to prevent transverse and longitudinal sliding. In addition, where a 40 ft container is required to be stowed above 20 ft containers, stacking cones are to be fitted at the ends of the 40 ft container between the 40 ft container and the 20 ft containers below.

(f) The 20 ft containers are to have closed steel walls and top (no open frame containers, e.g., tank or bulk containers).

(g) The orientation of the containers is to be such that all front ends or door ends are facing in one direction.

(h) Cones are to be fitted on the inner bottom in way of the cell guides to restrain container movement in the longitudinal direction.

(j) The containers are to be stowed in the hold in block stowage. In general, free standing stacks due to adjacent empty stacks are to be avoided.

Proposals for stowage arrangements other than the above will be individually considered and are to be accompanied by supporting calculations.

Table 14.7.1 Maximum container weights of ISO 1496-1:1990 20 ft containers stowed in 40 ft cell guides with no overstow; Container's rated Weight = 24 t

Lowest tier transverse acceleration (= a_y/g), *see* 8.2.5	Maximum homogeneous container weights, in tonnes									
	3 tiers	4 tiers	5 tiers	6 tiers	7 tiers	8 tiers	9 tiers	10 tiers	11 tiers	12 tiers
0,350	24,0	24,0	24,0	20,2	17,3	14,8	13,4	11,6	10,6	9,5
0,355	24,0	24,0	24,0	20,2	17,1	14,6	13,3	11,6	10,6	9,4
0,360	24,0	24,0	24,0	19,7	16,9	14,5	13,2	11,5	10,5	9,3
0,365	24,0	24,0	24,0	19,5	16,7	14,3	13,1	11,4	10,4	9,3
0,370	24,0	24,0	23,9	19,3	16,5	14,1	13,0	11,3	10,3	9,2
0,375	24,0	24,0	23,6	19,0	16,3	14,0	12,9	11,3	10,3	9,2
0,380	24,0	24,0	23,3	18,8	16,1	13,8	12,7	11,2	10,2	9,1
0,385	24,0	24,0	23,0	18,6	15,9	13,6	12,6	11,1	10,1	9,0
0,390	24,0	24,0	22,7	18,4	15,8	13,5	12,5	11,0	10,0	9,0
0,395	24,0	24,0	22,5	18,2	15,6	13,3	12,4	10,9	9,9	8,9
0,400	24,0	24,0	22,2	18,0	15,4	13,2	12,3	10,8	9,9	8,9
0,405	24,0	24,0	22,0	17,8	15,3	13,1	12,1	10,7	9,8	8,8
0,410	24,0	24,0	21,8	17,6	15,1	13,0	12,0	10,7	9,7	8,8
0,415	24,0	24,0	21,5	17,5	15,0	12,9	11,8	10,6	9,7	8,7
0,420	24,0	24,0	21,3	17,3	14,8	12,7	11,7	10,4	9,6	8,7
0,425	24,0	24,0	21,1	17,2	14,7	12,6	11,5	10,3	9,5	8,6
0,430	24,0	24,0	20,9	17,0	14,6	12,5	11,4	10,2	9,4	8,6
0,435	24,0	24,0	20,7	16,9	14,5	12,4	11,3	10,1	9,4	8,5
0,440	24,0	24,0	20,6	16,8	14,4	12,4	11,1	10,0	9,3	8,5
0,445	24,0	23,9	20,4	16,6	14,3	12,3	11,0	9,9	9,2	8,4
0,450	24,0	23,7	20,2	16,5	14,1	12,2	10,9	9,9	9,2	8,3
0,455	24,0	23,6	20,0	16,4	14,0	12,1	10,8	9,8	9,1	8,3
0,460	24,0	23,4	19,9	16,2	13,9	12,0	10,7	9,7	9,0	8,2
0,465	24,0	23,3	19,7	16,1	13,8	11,9	10,6	9,6	8,9	8,1
0,470	24,0	23,1	19,6	16,0	13,7	11,8	10,6	9,5	8,9	8,1
0,475	24,0	23,0	19,5	15,9	13,6	11,7	10,5	9,4	8,8	8,0
0,480	24,0	22,9	19,3	15,8	13,5	11,6	10,5	9,4	8,7	7,9
0,485	24,0	22,7	19,2	15,7	13,4	11,5	10,4	9,3	8,6	7,9
0,490	24,0	22,6	19,1	15,6	13,3	11,4	10,3	9,2	8,5	7,8
0,495	24,0	22,5	18,9	15,5	13,2	11,3	10,3	9,1	8,5	7,7
0,500	24,0	22,4	18,8	15,4	13,1	11,2	10,2	9,1	8,4	7,7
0,505	24,0	22,3	18,7	15,3	13,0	11,2	10,1	9,0	8,3	7,6
0,510	24,0	22,1	18,6	15,2	13,0	11,1	10,1	8,9	8,3	7,6
0,515	24,0	22,0	18,4	15,1	12,9	11,0	10,0	8,9	8,2	7,5
0,520	24,0	21,9	18,3	15,0	12,8	10,9	9,9	8,8	8,1	7,4
0,525	24,0	21,8	18,2	14,9	12,7	10,9	9,9	8,7	8,1	7,4
0,530	24,0	21,7	18,1	14,8	12,6	10,8	9,8	8,7	8,0	7,3
0,535	24,0	21,6	18,0	14,7	12,5	10,7	9,7	8,6	8,0	7,3
0,540	24,0	21,5	17,9	14,6	12,4	10,6	9,6	8,5	7,9	7,2
0,545	24,0	21,4	17,7	14,5	12,3	10,6	9,6	8,5	7,8	7,1
0,550	24,0	21,3	17,6	14,4	12,3	10,5	9,5	8,4	7,8	7,1
0,555	24,0	21,2	17,5	14,3	12,2	10,4	9,4	8,4	7,7	7,0
0,560	24,0	21,1	17,4	14,2	12,1	10,4	9,3	8,3	7,7	7,0
0,565	24,0	21,0	17,3	14,2	12,0	10,3	9,3	8,3	7,6	6,9
0,570	24,0	20,9	17,2	14,1	11,9	10,2	9,2	8,2	7,6	6,9
0,575	24,0	20,8	17,1	14,0	11,9	10,2	9,1	8,2	7,5	6,8
0,580	24,0	20,7	17,0	13,9	11,8	10,1	9,0	8,1	7,5	6,8
0,585	24,0	20,6	16,9	13,8	11,7	10,1	9,0	8,1	7,4	6,8
0,590	24,0	20,5	16,8	13,7	11,6	10,0	8,9	8,0	7,4	6,7
0,595	24,0	20,4	16,7	13,7	11,6	9,9	8,8	8,0	7,3	6,7
0,600	24,0	20,4	16,6	13,6	11,5	9,9	8,8	7,9	7,3	6,6
0,605	24,0	20,3	16,5	13,5	11,4	9,8	8,7	7,9	7,2	6,6
0,610	24,0	20,2	16,5	13,4	11,4	9,8	8,7	7,8	7,2	6,5
0,615	24,0	20,1	16,4	13,4	11,3	9,7	8,6	7,8	7,1	6,5
0,620	24,0	20,0	16,3	13,3	11,2	9,7	8,6	7,7	7,1	6,5
0,625	24,0	20,0	16,2	13,2	11,2	9,6	8,6	7,7	7,0	6,4
0,630	24,0	19,9	16,1	13,1	11,1	9,6	8,5	7,6	7,0	6,4
0,635	24,0	19,8	16,0	13,1	11,1	9,5	8,5	7,6	6,9	6,3
0,640	24,0	19,7	15,9	13,0	11,0	9,5	8,4	7,5	6,9	6,3
0,645	24,0	19,7	15,9	12,9	10,9	9,4	8,4	7,5	6,9	6,3
0,650	24,0	19,6	15,8	12,9	10,9	9,4	8,4	7,5	6,8	6,2

Table 14.7.2 **Maximum container weights of ISO 1496-1:1990 20 ft containers stowed in 40 ft cell guides with no overstow; Container's rated weight = 30,5 t**

Lowest tier transverse acceleration (= a_y/g), *see* 8.2.5	Maximum homogeneous container weights, in tonnes									
	3 tiers	4 tiers	5 tiers	6 tiers	7 tiers	8 tiers	9 tiers	10 tiers	11 tiers	12 tiers
0,350	30,5	28,1	25,0	20,2	17,3	14,8	13,4	11,6	10,6	9,5
0,355	30,5	27,8	24,7	20,0	17,1	14,6	13,3	11,6	10,5	9,4
0,360	30,5	27,6	24,4	19,7	16,9	14,5	13,2	11,5	10,5	9,3
0,365	30,5	27,3	24,1	19,5	16,7	14,3	13,1	11,4	10,4	9,3
0,370	30,5	27,0	23,9	19,3	16,5	14,1	13,0	11,3	10,3	9,2
0,375	30,5	26,7	23,6	19,0	16,3	14,0	12,9	11,3	10,2	9,2
0,380	30,5	26,4	23,3	18,8	16,1	13,8	12,7	11,2	10,2	9,1
0,385	30,5	26,2	23,0	18,6	15,9	13,6	12,6	11,1	10,1	9,0
0,390	30,5	25,9	22,7	18,4	15,8	13,5	12,5	11,0	10,0	9,0
0,395	30,5	25,7	22,5	18,2	15,6	13,3	12,4	10,9	9,9	8,9
0,400	30,5	25,4	22,2	18,0	15,4	13,2	12,3	10,8	9,9	8,9
0,405	30,5	25,2	22,0	17,8	15,3	13,1	12,1	10,7	9,8	8,8
0,410	30,5	25,0	21,8	17,6	15,1	13,0	12,0	10,7	9,7	8,8
0,415	30,5	24,8	21,5	17,5	15,0	12,9	11,8	10,6	9,7	8,7
0,420	30,5	24,7	21,3	17,3	14,8	12,7	11,7	10,4	9,6	8,7
0,425	30,5	24,5	21,1	17,2	14,7	12,6	11,5	10,3	9,5	8,6
0,430	30,5	24,3	20,9	17,0	14,6	12,5	11,4	10,2	9,4	8,6
0,435	30,5	24,2	20,7	16,9	14,5	12,4	11,3	10,1	9,4	8,5
0,440	30,5	24,0	20,6	16,8	14,4	12,4	11,1	10,0	9,3	8,5
0,445	30,5	23,9	20,4	16,6	14,3	12,3	11,0	9,9	9,2	8,4
0,450	30,5	23,7	20,2	16,5	14,1	12,2	10,9	9,9	9,2	8,3
0,455	30,5	23,6	20,0	16,4	14,0	12,1	10,8	9,8	9,1	8,3
0,460	30,5	23,4	19,9	16,2	13,9	12,0	10,7	9,7	9,0	8,2
0,465	30,5	23,3	19,7	16,1	13,8	11,9	10,6	9,6	8,9	8,1
0,470	30,5	23,1	19,6	16,0	13,7	11,8	10,6	9,5	8,9	8,1
0,475	30,5	23,0	19,5	15,9	13,6	11,7	10,5	9,4	8,8	8,0
0,480	30,5	22,9	19,3	15,8	13,5	11,6	10,5	9,4	8,7	7,9
0,485	30,5	22,7	19,2	15,7	13,4	11,5	10,4	9,3	8,6	7,9
0,490	30,5	22,6	19,1	15,6	13,3	11,4	10,3	9,2	8,5	7,8
0,495	30,5	22,5	18,9	15,5	13,2	11,3	10,3	9,1	8,5	7,7
0,500	30,5	22,4	18,8	15,4	13,1	11,2	10,2	9,1	8,4	7,7
0,505	30,5	22,3	18,7	15,3	13,0	11,2	10,1	9,0	8,3	7,6
0,510	30,4	22,1	18,6	15,2	13,0	11,1	10,1	8,9	8,3	7,6
0,515	30,4	22,0	18,4	15,1	12,9	11,0	10,0	8,9	8,2	7,5
0,520	30,4	21,9	18,3	15,0	12,8	10,9	9,9	8,8	8,1	7,4
0,525	30,4	21,8	18,2	14,9	12,7	10,9	9,9	8,7	8,1	7,4
0,530	30,4	21,7	18,1	14,8	12,6	10,8	9,8	8,7	8,0	7,3
0,535	30,3	21,6	18,0	14,7	12,5	10,7	9,7	8,6	8,0	7,3
0,540	30,3	21,5	17,9	14,6	12,4	10,6	9,6	8,5	7,9	7,2
0,545	30,1	21,4	17,7	14,5	12,3	10,6	9,6	8,5	7,8	7,1
0,550	30,1	21,3	17,6	14,4	12,3	10,5	9,5	8,4	7,8	7,1
0,555	29,9	21,2	17,4	14,3	12,2	10,4	9,4	8,4	7,7	7,0
0,560	29,8	21,1	17,4	14,2	12,1	10,4	9,3	8,3	7,7	7,0
0,565	29,6	21,0	17,3	14,2	12,0	10,3	9,3	8,3	7,6	6,9
0,570	29,4	20,9	17,2	14,1	11,9	10,2	9,2	8,2	7,6	6,9
0,575	29,1	20,8	17,1	14,0	11,9	10,2	9,1	8,2	7,5	6,8
0,580	28,9	20,7	17,0	13,9	11,8	10,1	9,0	8,1	7,5	6,8
0,585	28,7	20,6	16,9	13,8	11,7	10,1	9,0	8,1	7,4	6,8
0,590	28,5	20,5	16,8	13,7	11,6	10,0	8,9	8,0	7,4	6,7
0,595	28,3	20,4	16,7	13,7	11,6	9,9	8,8	8,0	7,3	6,7
0,600	28,2	20,4	16,6	13,6	11,5	9,9	8,8	7,9	7,3	6,6
0,605	28,1	20,3	16,5	13,5	11,4	9,8	8,7	7,9	7,2	6,6
0,610	28,0	20,2	16,5	13,4	11,4	9,8	8,7	7,8	7,2	6,5
0,615	28,0	20,1	16,4	13,4	11,3	9,7	8,6	7,8	7,1	6,5
0,620	28,0	20,0	16,3	13,3	11,2	9,7	8,6	7,7	7,1	6,5
0,625	27,9	20,0	16,2	13,2	11,2	9,6	8,6	7,7	7,0	6,4
0,630	27,9	19,9	16,1	13,1	11,1	9,6	8,5	7,6	7,0	6,4
0,635	27,9	19,8	16,0	13,1	11,1	9,5	8,5	7,6	6,9	6,3
0,640	27,9	19,7	15,9	13,0	11,0	9,5	8,4	7,5	6,9	6,3
0,645	27,9	19,7	15,9	12,9	10,9	9,4	8,4	7,5	6,9	6,3
0,650	27,9	19,6	15,8	12,9	10,9	9,4	8,4	7,5	6,8	6,2

Table 14.7.3 Maximum container weights of ISO 1496-1:1990 20 ft containers stowed in 40 ft cell guides with overstow

Lowest tier transverse acceleration (= a_y/g), *see* 8.2.5	Maximum homogeneous container weights, in tonnes					
	3 tiers	4 tiers	5 tiers	6 tiers	7 tiers	8 tiers
0,400	24,0	24,0	24,0	19,6	17,1	15,2
0,405	24,0	24,0	23,6	19,4	17,0	15,1
0,410	24,0	24,0	23,3	19,2	16,8	14,9
0,415	24,0	24,0	22,9	19,1	16,7	14,8
0,420	24,0	24,0	22,5	18,9	16,5	14,7
0,425	24,0	24,0	22,1	18,8	16,4	14,5
0,430	24,0	24,0	21,8	18,6	16,2	14,4
0,435	24,0	24,0	21,5	18,4	16,1	14,3
0,440	24,0	24,0	21,2	18,3	15,9	14,1
0,445	24,0	24,0	21,0	18,1	15,8	14,0
0,450	24,0	24,0	20,8	18,0	15,7	13,9
0,455	24,0	24,0	20,6	17,8	15,5	13,7
0,460	24,0	24,0	20,5	17,7	15,4	13,6
0,465	24,0	24,0	20,3	17,5	15,2	13,5
0,470	24,0	24,0	20,2	17,3	15,1	13,3
0,475	24,0	24,0	20,1	17,2	14,9	13,2
0,480	24,0	23,9	19,9	17,0	14,8	13,1
0,485	24,0	23,8	19,8	16,9	14,6	12,9
0,490	24,0	23,6	19,6	16,7	14,5	12,8
0,495	24,0	23,4	19,4	16,5	14,3	12,7
0,500	24,0	23,2	19,3	16,4	14,2	12,5
0,505	24,0	23,1	19,1	16,2	14,1	12,4
0,510	24,0	22,9	18,9	16,1	13,9	12,2
0,515	24,0	22,7	18,8	15,9	13,8	12,1
0,520	24,0	22,5	18,6	15,7	13,6	12,0
0,525	24,0	22,4	18,5	15,6	13,5	11,8
0,530	24,0	22,3	18,3	15,4	13,3	11,7
0,535	24,0	22,2	18,2	15,3	13,2	11,6
0,540	24,0	22,1	18,1	15,1	13,0	11,4
0,545	24,0	22,0	18,0	15,0	12,9	11,3
0,550	24,0	21,8	17,9	14,8	12,8	11,2

NOTE
40ft overstow containers not included in the number of tiers.

7.4 Cell guide systems on exposed decks

7.4.1 Analysis methods for the strength of the cell guide structure are to take due account of the interactive effects between guide structure and supporting deck structure and also of the deformation of the hull girder.

7.4.2 At its lower end the guide structure is to be efficiently connected to the deck structure. Cross ties are to be arranged between guides in a transverse direction at a spacing determined by the loading on the guides but in general not more than 3 m apart. Cross-bracing members of adequate strength and sufficient number are to be fitted in the transverse and longitudinal directions to prevent excessive deflection of the guide structure.

7.4.3 The height of guide bars above the deck is to be sufficient to ensure adequate restraint to the uppermost container tiers.

7.4.4 Where the cell guide structure is attached to highly stressed hull or deck elements, such as sheerstrakes, special attention is to be given to the design of the connection and the grade and quality of steel utilised.

7.5 Entry guide devices

7.5.1 A device to pre-centre the container and direct it into the cell guides is normally to be fitted at the top of the guide bars. Such devices include:

- fixed even peaks,
- fixed high and low peaks,
- 'flip-flop' systems,

but other devices will be considered. The device is to be of robust construction.

■ *Section 8*

Determination of forces for container securing arrangements

8.1 General

8.1.1 The forces acting in the securing system are to be determined for each loading condition and associated set of motions of the ship. Although the operation of anti-roll devices or other systems may improve the behaviour of the ship in a seaway, the effect of such devices is not to be taken into account to reduce the determination of the forces for container securing arrangements.

8.1.2 The following forces are to be taken into account:

- Static gravity forces.
- Inertial forces generated by the ship motions in a seaway.
- Wind forces.
- Forces imposed by the securing arrangements.
- Wave impact forces and effects of consequential hull girder whipping.

8.1.3 Forces due to pre-tensioning the securing devices need not, in general, be included in the calculation, provided that they do not exceed 5 kN in any one item. Special consideration will be given to cases where forces obtained from pre-stressing are an integral part of the design of the system.

8.2 Ship motion, wind and green sea forces acting on containers

8.2.1 The forces acting on each container due to gravity, ship motion accelerations, ship rolling and pitching angles and wind forces and green sea forces are to be calculated as follows.

8.2.2 The ship motion amplitude and period for roll and pitch motions are given in Table 14.8.1. The equations for ship motion accelerations and other motion parameters are given in 1.5. These are to be used for the calculation of accelerations to derive the forces for the container securing arrangements. Alternatively, the ship motion values may be derived by direct calculation methods using the same principles as those used to derive the Rule equations.

8.2.3 The following six Motion Cases (MCs) are to be considered:

MC1: Head sea case that maximises vertical acceleration
MC2: Beam sea case that maximises roll motion
MC3: Oblique sea case that maximises pitch acceleration
MC4: Oblique sea case with forward speed that maximises roll motion
MC5: Oblique sea case that maximises combined transverse and vertical accelerations
MC6: Beam sea case that maximises heave acceleration

Each Motion Case comprises 2 or 4 Motion Combination Factor (MCF) sets representing an incoming wave crest or trough coming from either the port or starboard sides. Each MCF set represents an Equivalent Design Wave (EDW) that generates response values equivalent to the long-term response values of the critical load components for ship motion forces acting on containers. The Motion Combination Factors are given in Table 14.8.4.

8.2.4 The individual force components for each Motion Case due to gravity, ship motions, wind and green seas acting on a container *i* are to be determined as follows, *see* Figs. 14.1.1 and 14.9.1:

H_{Di} = force acting on container *i* in kN in transverse direction parallel to deck, positive to port
= $W\,a_y + H_{Gi}$

J_{Di} = force acting on container *i* in kN in longitudinal direction parallel to deck, positive forward
= $W\,a_x + J_{Gi}$

P_{Di} = upwards force acting on container *i* in kN normal to deck
= $W\,a_z + P_{Gi}$

Q_{Di} = wind force acting on exposed container *i* in kN in transverse direction parallel to deck
= $C_{wf}\,b\,c_i\,V_W^2 \cos^2 (C_{yG}\,\phi) \times 10^{-4}$
where
C_{wf} is given in Table 14.8.2 and C_{yG} is given in Table 14.8.4

NOTES

1. Q_{Di} is only to be applied when Q_{Di} will increase the transverse force H_{Di}.
2. When the green sea force H_{Gi} is also applicable, the wind force is only to be applied to container *i* when the wind force Q_{Di} is greater than the green sea force H_{Gi} acting on container *i*. In this case the wind force is to be reduced such that the total combined green sea and wind force is not greater than the originally calculated wind force.
3. *See also* 8.2.6 and 8.2.7.

H_{Gi} = green sea force acting on container *i*, in kN in transverse direction parallel to deck, positive to port
= $-b\,c_i\,P_{gs}$ for port side exposed containers
= $b\,c_i\,P_{gs}$ for starboard side exposed containers

J_{Gi} = green sea force acting on container *i*, in kN in longitudinal direction parallel to deck, positive forward
= $-a\,c_i\,P_{gs}$

P_{Gi} = green sea force acting on container *i*, in kN in the upwards direction normal to deck
= $1{,}5a\,b$

where

P_{gs} = green sea pressure in kN/m^2, *see* 8.2.8 and 8.2.9.

8.2.5 The total instantaneous acceleration values acting on container *i*, including the static gravitational term, are to be taken as:

- Longitudinal acceleration (parallel to deck, positive forward)
  $a_x = C_{xS}\,a_{surge} + C_{xP}\,a_{pitch}\,z_i - g \sin (C_{xG}\,\psi)$ m/s^2
- Transverse acceleration (parallel to deck, positive to port)
  $a_y = C_{yS}\,a_{sway} - C_{yR}\,a_{roll}\,z_i + g \sin (C_{yG}\,\phi)$ m/s^2
- Vertical acceleration (normal to deck, positive upwards)
  $a_z = C_{p1}\,(C_{zH}\,a_{heave} + C_{zR}\,a_{roll}\,y_i - f_{ap}\,C_{zP}\,a_{pitch}\,x_i) - g \cos (C_{xG}\,\psi) \cos (C_{yG}\,\phi)$ m/s^2

where the Motion Combination Factors C_{xS}, C_{xP}, C_{xG}, C_{yS}, C_{yR}, C_{yG}, C_{zH}, C_{zR} and C_{zP} for each Motion Case are given in Table 14.8.4.

Table 14.8.1 Ship motions

Motion	Maximum single amplitude, in degrees	Period, in seconds
Roll	$\phi = 55 f_{BK}\, f_{HsR}\, e^{(-0{,}025B)}$ ϕ is not to be taken less than f_{HsR} 22° but need not exceed 30°	$T_r = \dfrac{0{,}82B}{\sqrt{G\,M}}$
Pitch	$\psi = 1350L^{-0{,}94}\left(1{,}0+\left(\dfrac{0{,}82}{\sqrt{L}}\right)^{1{,}2}\right) f_{HsP}$ ψ need not exceed 8°	$T_p = 0{,}80\sqrt{C_1\,L}$ where C_1 = 0,95 for MC1 = 0,52 for all other Motion Cases

Table 14.8.2 Wind force coefficient C_{wf}

Motion Case *see* Note 1	Wind force coefficient C_{wf}	
	Incoming wave from port (1P and 2P cases)	Incoming wave from starboard (1S and 2S cases)
	Only applied to the port exposed faces of containers, *see* Note 3	Only applied to the starboard exposed faces of containers, *see* Note 3
MC1, *see* Note 2	0	0
MC2	–8,25	8,25
MC3	–7,18	7,18
MC4	–7,18	7,18
MC5	–7,18	7,18
MC6	–8,25	8,25

NOTES
1. For definition of Motion Cases, *see* 8.2.3.
2. No wind loads are to be applied to Motion Case MC1.
3. For definition of exposed faces, *see* 8.2.7.

8.2.6 Wind forces are generally to be based on a maximum wind speed, V_w, of 40 m/s. Only positive forces of wind pressure are to be applied; suction forces need not be included.

8.2.7 Wind forces are to be taken as acting athwartships on the exposed faces of the container stack. Where the air gap between adjacent rows of containers does not exceed one metre, wind forces on the adjacent inner stack may be taken as zero. Where the air gap is 5 m or more, the adjacent inner stack is to be treated as fully exposed. Wind forces on the inner stack for intermediate air gaps may be obtained by linear interpolation, *see* Fig. 14.8.1.

Wind exposed, partial wind exposed and protected containers

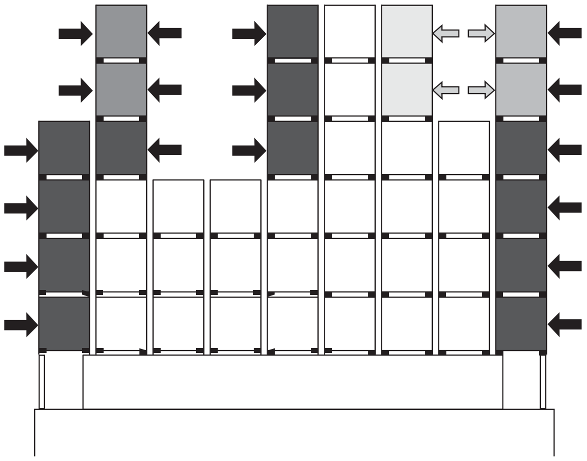


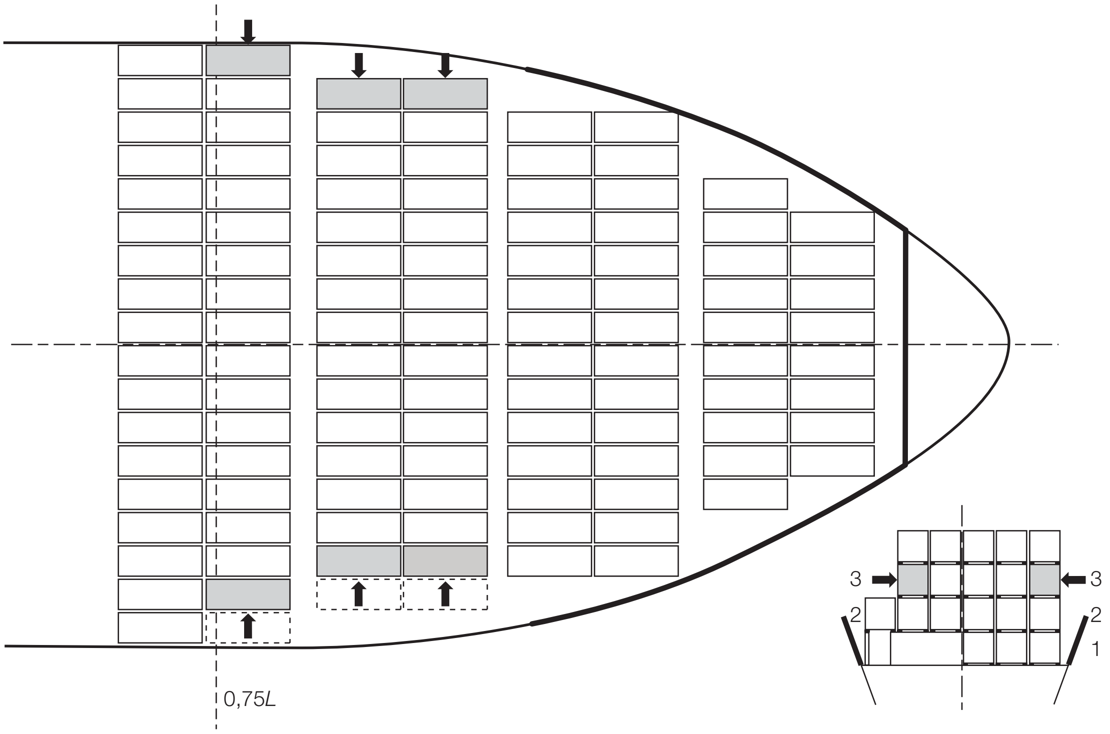
Fig. 14.8.1 Application of wind forces

8.2.8 The green sea force is to be applied as follows, *see* Fig 14.8.2:

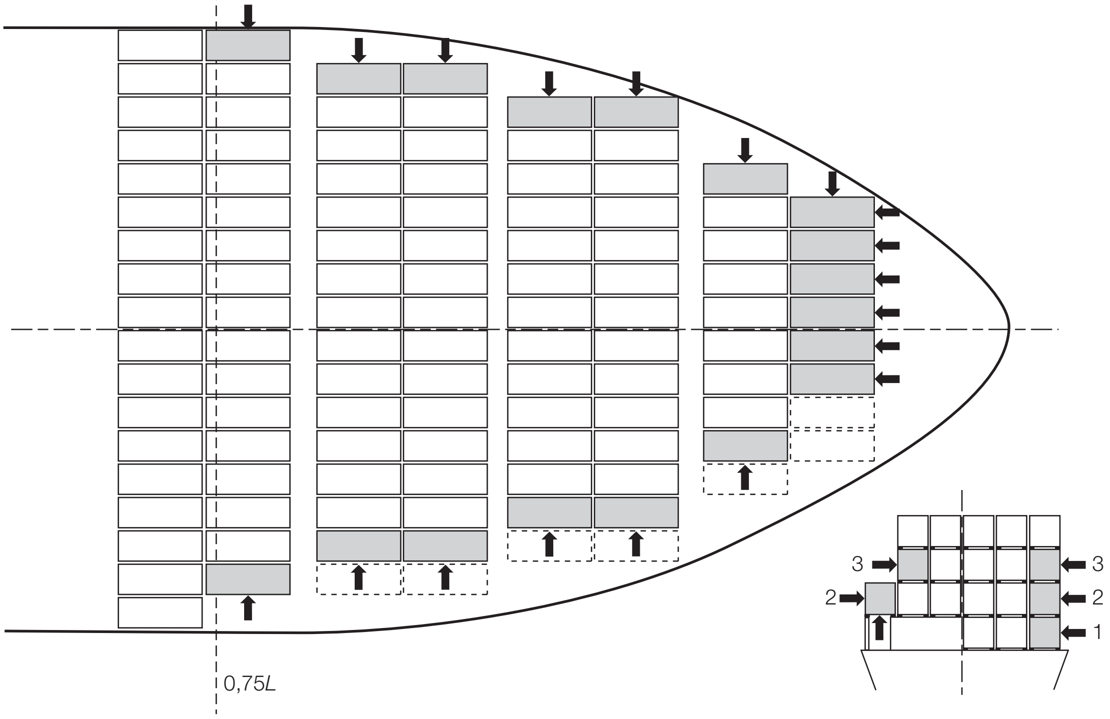
- When the transverse force H_{Di} is acting inwards, the green sea force H_{Gi} is to be added to H_{Di} for each container in the lowest three tiers of the outermost two stack positions where $x_c > 0{,}75L$, unless they are protected by another container or effective wraparound breakwater or equivalent.
- When the longitudinal force J_{Di} is acting aftwards, the green sea force J_{Gi} is to be added to J_{Di} for each container in the lowest three tiers where $x_c > 0{,}75L$, unless the forward end of the container is protected by another container or effective breakwater or equivalent.
- When the vertical acceleration $a_z > -9{,}81 \text{m/s}^2$ (less than g), the green sea force P_{Gi} is to be added to P_{Di} on the exposed underside of the lowest outboard container where $x_c > 0{,}75L$. The underside is considered exposed if it is raised above the hatch cover or deck by more than 0,5 m and not protected by an effective breakwater or equivalent.

NOTE

In general, Tier 1 position corresponds to lowest tier of containers sitting just above the deck and Tier 2 position corresponds to the lowest tier of containers sitting just above the hatch covers, *see* Fig. 14.8.2.



(a) Green sea loading on lowest three tiers only – Effective breakwaters (Forward and wrap around)



(b) Green sea loading on lowest three tiers only – No effective breakwater

Fig. 14.8.2 Example of application of green sea forces

8.2.9 The green sea pressure is given by:

for $L > 100$

$P_{gs} = C_{G1} L^2 + C_{G2} L + C_{G3}$ kN/m^2 but not less than 0

for $L \leq 100$, P_{gs} is to be taken as:

= 1,5 for Tier 1
= 1,0 for Tier 2
= 0,5 for Tier 3

where

C_{G1}, C_{G2}, C_{G3} are defined in Table 14.8.3

Proposals to use other values for green sea forces will be specially considered.

Table 14.8.3 Green sea pressure coefficients

	C_{G1}	C_{G2}	C_{G3}
Tier 1	–0,000017	0,0035	1,32
Tier 2	–0,000020	0,0040	0,80
Tier 3	–0,000023	0,0045	0,28

■ *Section 9*
Strength of container securing arrangements

9.1 General

9.1.1 The securing system is to be designed on the basis of the most severe combination of the forces specified in Section 8 in such a manner that the resultant forces on the containers and securing devices are within allowable limits. Where different arrangements of securing devices are proposed for different locations on the ship, the forces are to be calculated for the most severe condition applicable to each arrangement.

9.1.2 The resultant forces in the containers are not to exceed the allowable values given in 9.6.

9.1.3 The resultant forces in the securing devices and supports are not to exceed the allowable working loads for which the device has been approved, *see* Sections 2 and 3.

9.1.4 The forces in lashing devices, where fitted, are not to exceed the allowable safe working loads (SWLs) of the lashings as determined from Section 3.

9.2 Applied forces to each container

9.2.1 The applied forces due to ship motion and environmental loads acting on each container in the stack in accordance with Section 8 are illustrated in Fig.14.9.1 and are assumed to be divided equally between the walls of the container, as follows:

H_i = transverse force on each end wall = $\dfrac{H_{Di}}{2}$ kN

J_i = longitudinal force on each side wall = $\dfrac{J_{Di}}{2}$ kN

P_i = vertical downwards force at the bottom of each corner post = $\dfrac{-P_{Di}}{4}$ kN

Q_i = wind force on each end wall = $\dfrac{Q_{Di}}{2}$ kN

The subscript i refers to any particular container.

9.2.2 Forces H_i and J_i are assumed to act at one third of the height of the container above its base. These forces are distributed as follows:

$\dfrac{H_i}{3}\left(\text{or } \dfrac{J_i}{3}\right)$ acting at the top of the container, and

$\dfrac{2H_i}{3}\left(\text{or } \dfrac{2J_i}{3}\right)$ acting at the bottom.

9.2.3 Wind force is assumed to be uniformly distributed over the side of the container and is therefore divided equally between the top and bottom of the container.

9.3 Total resulting forces in an unlashed stack

9.3.1 Where the stack is supported only by approved devices between the tiers of containers and at the base of the stack, the total forces in the stack are determined from Table 14.9.1. Fig.14.9.1 illustrates the applied forces acting on each container and the resulting total forces.

9.3.2 For exposed stacks forward of 0,75*L*, *see* 8.1.4.

9.3.3 To illustrate this calculation, the equations for calculation of the transverse forces only for the three-tier stack shown in Fig. 14.9.1 are listed below. For simplicity, the equations below do not include the longitudinal forces. The complete method to combine longitudinal and transverse forces for an unlashed stack is given in Table 14.9.1.

(a) Transverse racking force in each end wall:

Tier 3: $RA_{y3} = F_3$
Tier 2: $RA_{y2} = F_3 + F_2$
Tier 1: $RA_{y1} = F_3 + F_2 + F_1$

(b) Transverse shear force at each bottom corner fitting:

Tier 3: $SF_{y3} = 0{,}55\,(H_3 + Q_3)$
Tier 2: $SF_{y2} = 0{,}55\,(H_3 + H_2 + Q_3 + Q_2)$
Tier 1: $SF_{y1} = 0{,}55\,(H_3 + H_2 + H_1 + Q_3 + Q_2 + Q_1)$

(c) Compressive force at bottom of each port side corner post (i.e., force on the container below):

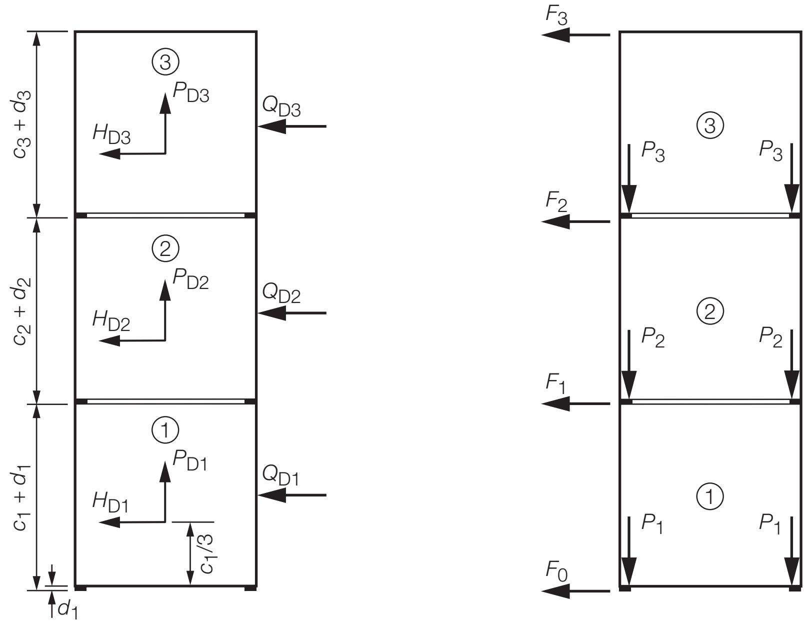
Tier 3: $V_{p3} = P_3 + \dfrac{F_3}{a}(c_3 + d_3)$

Tier 2: $V_{p2} = P_3 + P_2 + \dfrac{F_3}{a}(c_3 + c_2 + d_3 + d_2) + \dfrac{F_2}{a}(c_2 + d_2)$

Tier 1: $V_{p1} = P_3 + P_2 + P_1 + \dfrac{F_3}{a}(c_3 + c_2 + c_1 + d_3 + d_2 + d_1) + \dfrac{F_2}{a}(c_2 + c_1 + d_2 + d_1) + \dfrac{F_1}{a}(c_1 + d_1)$

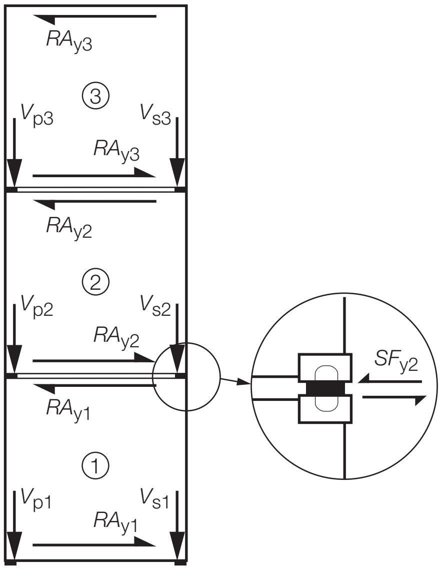
Table 14.8.4 Motion Combination Factors (MCFs)

Motion Case	Heading	Incoming wave	MCF	Longitudinal acceleration			Transverse acceleration			Vertical acceleration		
				a-surge	*a*-pitch	*g**sinψ	*a*-sway	*a*-roll	*g**sinϕ	*a*-heave	*a*-roll	*a*-pitch
				C_{xS}	C_{xP}	C_{xG}	C_{yS}	C_{yR}	C_{yG}	C_{zH}	C_{zR}	C_{zP}
MC1	Head	From Bow	HS_1	–0,69	1,00	–0,85	0,00	0,00	0,00	–0,18	0,00	1,00
			HS_2	0,69	–1,00	0,85	0,00	0,00	0,00	0,18	0,00	–1,00
MC2	Beam	From PS	BS_1P	0,00	0,00	0,00	–0,09	0,66	–0,66	0,14	0,66	0,00
			BS_2P	0,00	0,00	0,00	0,09	–0,66	0,66	–0,14	–0,66	0,00
		From STB	BS_1S	0,00	0,00	0,00	0,09	–0,66	0,66	0,14	–0,66	0,00
			BS_2S	0,00	0,00	0,00	–0,09	0,66	–0,66	–0,14	0,66	0,00
MC3	Oblique	From PS	OS1_1P	–0,43	1,00	–0,86	–0,28	–0,22	0,05	–0,29	–0,22	1,00
			OS1_2P	0,43	–1,00	0,86	0,28	0,22	–0,05	0,29	0,22	–1,00
		From STB	OS1_1S	–0,43	1,00	–0,86	0,28	0,22	–0,05	–0,29	0,22	1,00
			OS1_2S	0,43	–1,00	0,86	–0,28	–0,22	0,05	0,29	–0,22	–1,00
MC4	Oblique	From PS	OS2_1P	0,00	0,00	0,00	–0,02	1,00	–1,00	0,00	1,00	0,00
			OS2_2P	0,00	0,00	0,00	0,02	–1,00	1,00	0,00	–1,00	0,00
		From STB	OS2_1S	0,00	0,00	0,00	0,02	–1,00	1,00	0,00	–1,00	0,00
			OS2_2S	0,00	0,00	0,00	–0,02	1,00	–1,00	0,00	1,00	0,00
MC5	Oblique	From PS	OS3_1P	0,62	–0,46	0,65	0,96	–0,36	0,12	0,11	–0,36	–0,46
			OS3_2P	–0,62	0,46	–0,65	–0,96	0,36	–0,12	–0,11	0,36	0,46
		From STB	OS3_1S	0,62	–0,46	0,65	–0,96	0,36	–0,12	0,11	0,36	–0,46
			OS3_2S	–0,62	0,46	–0,65	0,96	–0,36	0,12	–0,11	–0,36	0,46
MC6	Beam	From PS	BS2_1P	–0,07	–0,05	0,02	0,62	0,12	–0,01	1,00	0,12	–0,05
			BS2_2P	0,07	0,05	–0,02	–0,62	–0,12	0,01	–1,00	–0,12	0,05
		From STB	BS2_1S	–0,07	–0,05	0,02	–0,62	–0,12	0,01	1,00	–0,12	–0,05
			BS2_2S	0,07	0,05	–0,02	0,62	0,12	–0,01	–1,00	0,12	0,05



(i) Applied loads to each container

(ii) Resultant applied forces for each container



(iii) Resultant shear and compressive forces in each end of an unlashed stack

Fig. 14.9.1 Force derivation at one end of a three-tier stack

(d) Compressive force at bottom of each starboard side corner post (i.e., force on the container below):

Tier 3: $V_{s3} = P_3 - \frac{F_3}{a}(c_3 + d_3)$

Tier 2: $V_{s2} = P_3 + P_2 - \frac{F_3}{a}(c_3 + c_2 + d_3 + d_2) - \frac{F_2}{a}(c_2 + d_2)$

Tier 1: $V_{s1} = P_3 + P_2 + P_1 - \frac{F_3}{a}(c_3 + c_2 + c_1 + d_3 + d_2 + d_1) - \frac{F_2}{a}(c_2 + c_1 + d_2 + d_1) - \frac{F_1}{a}(c_1 + d_1)$

A negative value in equations (c) and (d) indicates a separation force at that level.

Table 14.9.1 Total resulting forces in each end/side wall of an unlashed stack

Force	Equations for an unlashed stack
(a) Racking force in end/side wall of container *i*	
Transverse	$RA_{yi} = \sum_{j=i}^{N} F_j$ kN where the transverse force at level *j* is given by $F_j = \frac{2H_{(j+1)}}{3} + \frac{H_j}{3} + \frac{Q_{(j+1)}}{2} + \frac{Q_j}{2}$ kN for $j < N$ and $F_j = \frac{H_j}{3} + \frac{Q_j}{2}$ kN for $j = N$
Longitudinal	$RA_{xi} = \sum_{j=i}^{N} G_j$ kN where the longitudinal force at level *j* is given by $G_j = \frac{2J_{(j+1)}}{3} + \frac{J_j}{3}$ kN for $j < N$ and $G_j = \frac{J_j}{3}$ kN for $j = N$
(b) Shear force acting at bottom corner device of container *i*	
Transverse	$SF_{yi} = 0{,}55 \sum_{j=i}^{N} (H_j + Q_j)$ kN
Longitudinal	$SF_{xi} = 0{,}55 \sum_{j=i}^{N} J_j$ kN
Total shear force	$SF_i = \sqrt{SF_{xi}^2 + SF_{yi}^2}$ kN
(c) Compressive force in each corner post of container *i*	
Port fwd	$V_{pfi} = \sum_{j=i}^{N} P_j + \frac{1}{a} \sum_{j=i}^{N} F_j h_{ij} + \frac{1}{b} \sum_{j=i}^{N} G_j h_{ij}$ kN
Port aft	$V_{pai} = \sum_{j=i}^{N} P_j + \frac{1}{a} \sum_{j=i}^{N} F_j h_{ij} - \frac{1}{b} \sum_{j=i}^{N} G_j h_{ij}$ kN
Starboard fwd	$V_{sfi} = \sum_{j=i}^{N} P_j - \frac{1}{a} \sum_{j=i}^{N} F_j h_{ij} + \frac{1}{b} \sum_{j=i}^{N} G_j h_{ij}$ kN
Starboard aft	$V_{sai} = \sum_{j=i}^{N} P_j - \frac{1}{a} \sum_{j=i}^{N} F_j h_{ij} - \frac{1}{b} \sum_{j=i}^{N} G_j h_{ij}$ kN

Symbols

h_{ij} is the height from the bottom of the fitting (e.g., twistlock) below corner post *i* to the top of container *j,* in metres

$$h_{ij} = \sum_{k=i}^{J} (c_k + d_k)$$

N is the total numbers of tiers

Q_j is only applied to the exposed container faces

9.3.4 The transverse displacements of the container stack are to be calculated as follows. The displacement of the top corner of container *i* under the actions of the applied forces is given by:

$$\delta_{yi} = \sum_{j=1}^{i} \left(\frac{RA_{yj}}{k_{cy}} \right) \text{ mm}$$

δ_{yi} is to be calculated for each end wall of the container

where

RA_{yi} = transverse racking force in end wall of container *i*, *see also* Table 14.9.1

$$= \sum_{j=1}^{N} F_j \text{ kN}$$

k_{cy} = shear spring stiffness of the end wall being considered, *see* Table 14.9.2.

Table 14.9.2 Shear spring stiffness of container walls

Container height, metres		Door end kN/mm	Closed end kN/mm	Side wall kN/mm
2,438	(8 ft)	3,7	16,7	6,1
2,591	(8 ft 6 in)	3,5	15,4	5,7
2,743	(9 ft)	3,3	14,3	5,4
2,896	(9 ft 6 in)	3,2	13,3	5,1

Table 14.9.3 Effective modulus of elasticity of lashing devices

Lashing equipment	Effective modulus of elasticity (E_r) *see* 9.5.2
Steel rod lashings of hook type, including turnbuckle	98 kN/mm^2
Short (one tier) steel rod lashings (knob type), including turnbuckle and lashing eyes	140 kN/mm^2
Long (two tier) steel rod lashings (knob type), including turnbuckle and lashing eyes	175 kN/mm^2
Steel wire rope lashings	90 kN/mm^2
Steel chain lashings (based on the nominal diameter of the chain)	80 kN/mm^2
Adjustable tension/compression buttress	120 kN/mm^2
Aluminium or other materials	To be specially considered

9.3.5 The longitudinal displacements of the container stack are to be calculated as follows. The displacement of the top corner of container *i* under the actions of the applied forces is given by:

$$\delta_{xi} = \sum_{j=1}^{i} \left(\frac{RA_{xj}}{k_{cx}} \right) \text{ mm}$$

δ_{xi} is to be calculated for each side wall of the container.

9.4 Total resulting forces in a stack incorporating lashings

9.4.1 Where the securing arrangements incorporate lashings, proper allowance is to be made for flexibility of the system. For this purpose, the following values may be adopted:

(a) **Racking deformation of the container**. Full scale testing of containers indicates that values of the shear spring stiffness constant (*see* Fig. 14.9.2) may be taken as in Table 14.9.2.

(b) **Horizontal movement of the containers**. Initial displacement of containers due to tolerances in container fittings will be considered in conjunction with the stowage arrangement proposed. Generally, initial displacement may be neglected in calculation procedures for conventional stowages.

(c) **Elongation of the lashings**. Elongation may be determined by reference to an effective cross-sectional area of lashing device and an effective modulus of elasticity of the lashing (allowance for straightening and stretching), which in the absence of actual test values may be taken as specified in Table 14.9.3.

9.4.2 Any other element introducing flexibility into the structure between the lashing point and the base of the container stack is to be evaluated and taken into account, if necessary. Examples of this could be flexibility of a lashing bridge, sliding of a hatch cover or torsional deformations of the hull.

9.4.3 The following lashing devices may be used:

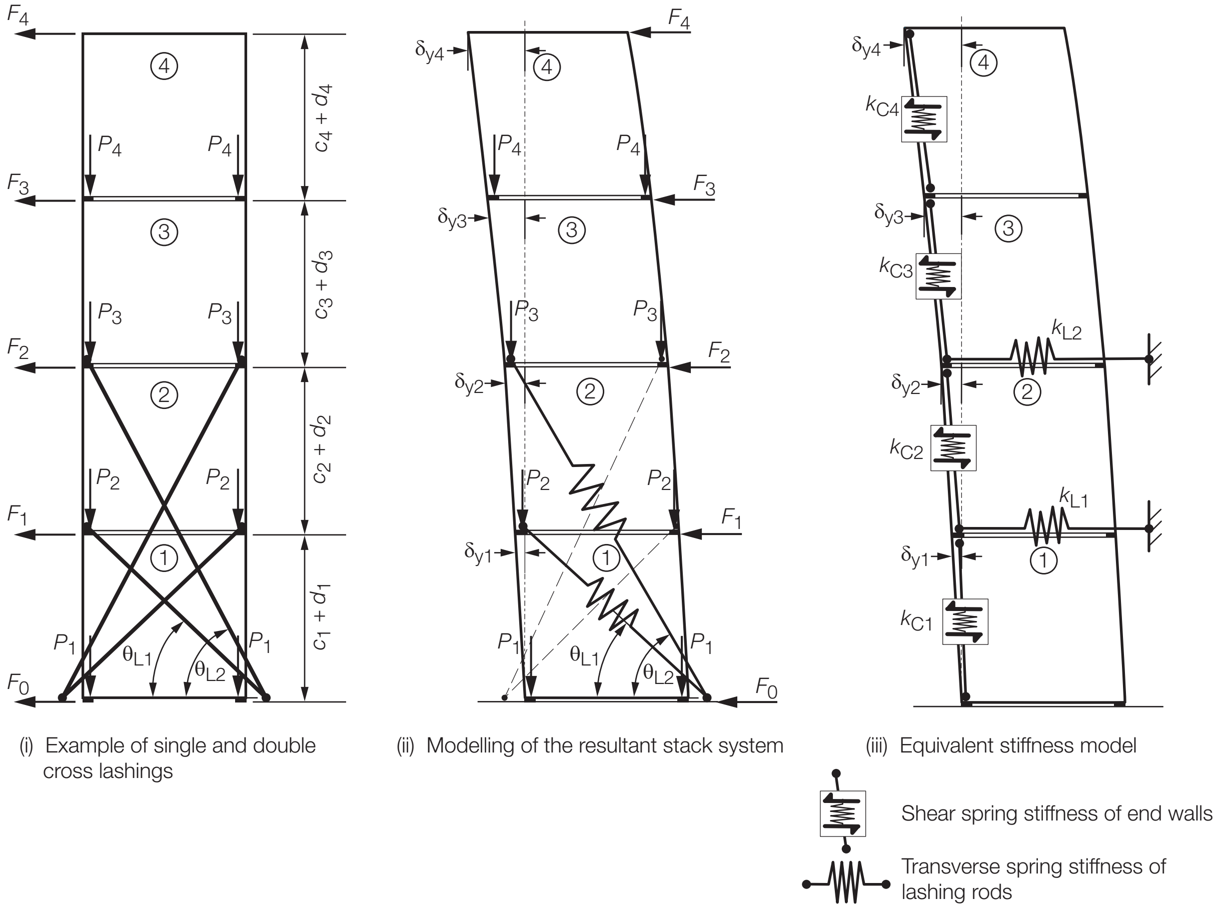
- A shore device or similar that only accepts compressive loads, *see* 6.1.7. This may be modelled in a similar way to a lashing rod. However, where more than one stack is supported by the use of linkages between adjacent containers in line with the shore, the calculation model is to take this into account.
- A lashing bridge to allow lashing devices to be arranged high up in the container stack. Where open framework systems are fitted on deck to provide structural restraint, they are to be designed to absorb the full horizontal component of force at that level and to prevent movement of the container stack. For the purpose of these calculations, the deformation of the ship's structure in way of supports may be neglected.
- A buttress connection or tension/compression device that accepts compressive and tensile forces, *see* 6.1.6. These are normally used for hold stowage. Where more than one stack is supported by the use of linkages between adjacent containers in line with the buttress, the calculation model is to take this into account.

9.4.4 The applied forces due to ship motion and environmental loads on containers in the stack are to be determined in accordance with 9.2.

9.4.5 The tensile or compressive forces in lashing devices supporting the container stack are to be determined in accordance with 9.5.

9.4.6 The load system for a four-tier stack of containers with transverse upper and lower lashings is illustrated in Fig. 14.9.2. The containers and lashings are modelled as a system of springs whose stiffness may be calculated and hence the equilibrium condition for the system may be found, *see* Fig. 14.9.2(iii).

9.4.7 The calculations are to be made for each end of the container stack, that is, with all door ends together and with all closed ends together, and also for each side wall.



(i) Example of single and double cross lashings

(ii) Modelling of the resultant stack system

(iii) Equivalent stiffness model

Fig. 14.9.2 Example of lashings at one end of a four-tier stack

9.4.8 The transverse displacements of the container stack are to be calculated as follows. The displacement of the top corner of container *i* under the actions of the applied forces and supporting lashing devices is given by:

$$\delta_{yi} = \sum_{j=1}^{i} \left(\frac{RA_{yj}}{k_{cy}} \right) \text{ mm}$$

δ_{yi} is to be calculated for each end wall of the container, taking into account lashing devices attached to the top corner of container *i* and the bottom corner of container (*i* + 1)

where

RA_{yi} = transverse racking force in end wall of container *i*, taking into account lashing rods and otherlashing devices attached to the top corner of container *i* and above attached to the end wall being considered, *see also* Table 14.9.4

$$= \sum_{j=i}^{N} F_j + \sum_{r=1}^{R} TL_{yr} \text{ kN}$$

k_{cy} = shear spring stiffness of the end wall being considered, *see* Table 14.9.2

TL_{yr} = force in lashing device *r*, measured in the transverse direction, *see* 9.5.

9.4.9 The longitudinal displacements of the container stack are to be calculated as follows. The displacement of the top corner of container *i* under the actions of the applied forces and supporting lashing devices is given by:

$$\delta_{xi} = \sum_{j=1}^{i} \left(\frac{RA_{xj}}{k_{cx}} \right) \text{ mm}$$

δ_{xi} is to be calculated for each side wall of the container, taking into account lashing devices attached to the top corner of container *i* and the bottom corner of container (*i* + 1).

9.4.10 The final distribution of forces in the stack is to be obtained by equating the total transverse displacements of the container stack δ_{yi} due to the applied loads with the transverse elongations in the attached lashing devices ε_{Lyr}. This is illustrated in Fig. 14.9.2. Hence, at each lashing device, the following equation is to be satisfied:

$$\delta_{yi} = \varepsilon_{Lyr} \text{ mm}$$

where

ε_{Lyr} = elongation or strain in the transverse direction in the lashing device, in mm.

9.4.11 The equations for deriving the total forces in the stack with lashings are given in Table 14.9.4. The final distribution of forces in a stack can also be solved using matrix methods.

Table 14.9.4 Total resulting forces in each end/side wall of a lashed stack

Force	Equations for lashed stack
(a) Racking force in end/side wall of container *i* Taking into account lashing rods and other lashing devices attached to the top corner of container *i* and above	
Transverse	$RA_{yi} = \sum_{j=i}^{N} F_j + \sum_{r=1}^{R} TL_{yr}$ kN To be evaluated for each end wall of the container taking into account lashing devices attached to the wall being considered
Longitudinal	$RA_{xi} = \sum_{j=i}^{N} G_j + \sum_{r=1}^{R} TL_{xr}$ kN To be evaluated for each side wall of the container taking into account lashing devices attached to the wall being considered
(b) Shear force acting at bottom corner device (or similar) of container *i* Taking into account lashing rods and other lashing devices attached to the bottom corner of container *i* and above	
Transverse	$SF_{yi} = 0{,}55 \sum_{j=i}^{N} (H_j + Q_j) + 0{,}55 \sum_{r=1}^{R} TL_{yr}$ kN To be evaluated for each end wall of the container, taking into account lashing devices attached to the wall being considered
Longitudinal	$SF_{xi} = 0{,}55 \sum_{j=i}^{N} (J_j) + 0{,}55 \sum_{r=1}^{R} TL_{xr}$ kN To be evaluated for each side wall of the container, taking into account lashing devices attached to the wall being considered
Total shear force	$SF_i = \sqrt{SF_{xi}^2 + SF_{yi}^2}$ kN To be evaluated for each corner
(c) Compressive force in each corner post of container *i* Taking into account lashing rods and other lashing devices attached to the top corner of container *i* and above. The lashing device forces appropriate to the wall and corner are to be taken into account	
Port fwd	$V_{pfi} = \sum_{j=i}^{N} P_j + \frac{1}{a} \sum_{j=i}^{N} F_j h_{ij} + \frac{1}{b} \sum_{j=i}^{N} G_j h_{ij} + \sum_{r=1}^{R} TL_r \sin\theta_{Lr} + \frac{1}{a} \sum_{r=1}^{R} TL_{yr} h_{ir} + \frac{1}{b} \sum_{r=1}^{R} TL_{xr} h_{ir}$ kN
Port aft	$V_{pai} = \sum_{j=i}^{N} P_j + \frac{1}{a} \sum_{j=i}^{N} F_j h_{ij} - \frac{1}{b} \sum_{j=i}^{N} G_j h_{ij} + \sum_{r=1}^{R} TL_r \sin\theta_{Lr} + \frac{1}{a} \sum_{r=1}^{R} TL_{yr} h_{ir} - \frac{1}{b} \sum_{r=1}^{R} TL_{xr} h_{ir}$ kN
Starboard fwd	$V_{sfi} = \sum_{j=i}^{N} P_j - \frac{1}{a} \sum_{j=i}^{N} F_j h_{ij} + \frac{1}{b} \sum_{j=i}^{N} G_j h_{ij} + \sum_{r=1}^{R} TL_r \sin\theta_{Lr} - \frac{1}{a} \sum_{r=1}^{R} TL_{yr} h_{ir} + \frac{1}{b} \sum_{r=1}^{R} TL_{xr} h_{ir}$ kN
Starboard aft	$V_{sai} = \sum_{j=i}^{N} P_j - \frac{1}{a} \sum_{j=i}^{N} F_j h_{ij} - \frac{1}{b} \sum_{j=i}^{N} G_j h_{ij} + \sum_{r=1}^{R} TL_r \sin\theta_{Lr} - \frac{1}{a} \sum_{r=1}^{R} TL_{yr} h_{ir} - \frac{1}{b} \sum_{r=1}^{R} TL_{xr} h_{ir}$ kN
(d) Compressive/lifting force at the bottom fitting of each corner post of container *i* Taking into account lashing rods and other lashing devices attached to the bottom corner of container *i* and above. The lashing device forces appropriate to the wall and corner are to be taken into account. The equations for the ‘Compressive force in each corner post’ are applied except that the lashing rods attached to the bottom of the container are included. This only affects the $\sum_{r=1}^{R} TL_r \sin\theta_{Lr}$ term	
Symbols	
h_{ir}	is the height from the bottom of the lower corner device of container *i* to lashing point *r*, in metres
R	is the total number of lashing devices
Q_j	is only applied to the exposed container faces

9.4.12 Similar calculations are to be applied in the longitudinal direction if any lashing device will resist longitudinal forces. For such lashings, the fixed lashing plates are to be suitably arranged to accommodate the additional forces due to the fore and aft inclination of the lashing rods. In addition, the design of the lashing rod head should be suitable for the angle of inclination of the lashing rod.

9.4.13 The above stiffness model assumes that the securing devices between tiers of containers are capable of resisting negative (separation) forces. That is, where separation forces are found, suitable locking devices are assumed to be fitted and transmitting load. When this is not the case, special consideration of the vertical displacements of the corners and forces in the lashing devices is necessary.

9.5 Forces in the lashing devices

9.5.1 The tensile or compressive force in a lashing device is given by:

$TL_r = \varepsilon_{Lr} k_{Lr}$ kN

The lashing device force in the positive transverse direction (i.e., positive to port) is given by:

$TL_{yr} = \varepsilon_{Lr} k_{Lr} \cos\theta_{Lr} \sin\theta_{Lxyr}$ kN

The lashing device force in the positive longitudinal direction (i.e., positive forwards) is given by:

$TL_{xr} = \varepsilon_{Lr} k_{Lr} \cos\theta_{Lr} \sin\theta_{Lxyr}$ kN

where

k_{Lr} = stiffness of lashing rod or device *r*, in kN/mm, *see* 9.4.1.

9.5.2 The stiffness of a lashing rod may be derived as follows:

$$k_{Lr} = \frac{E_r A_r}{l_r} \text{ kN/mm}$$

if E_r and A_r are specified otherwise k_{Lr} may be directly specified

E_r = effective modulus of elasticity, *see* Table 14.9.3

A_r = cross-sectional area of lashing device

For a para-lash arrangement, where two lashing devices are modelled as a single device, the effective area is to be taken as 1,5 times the area of one device. If each device in a para-lash arrangement is modelled, the effective area for each device is to be taken as 0,75 times the area of the single device.

ε_{Lr} = total elongation, in mm, of lashing rod or device *r*

$$\varepsilon_{Lr} = \sqrt{(l_x - \delta_{xib})^2 + (l_y - \delta_{yib})^2 + (l_z + \delta_{zib})^2} - l_r$$

$\varepsilon_{Lr} \geq 0$ for a lashing rod device

$\varepsilon_{Lr} \leq 0$ for a shore device (compression-only device), *see* 6.1.7

ε_{Lr} can be negative or positive for a buttress lashing connection or tension/compression lashing device, *see* 6.1.6

i_b = $i - 1$ if lashing device is connected to the bottom of the container

i_b = i if lashing device is connected to the top of the container

l_x = longitudinal distance of lashing foundation from container corner fitting, in mm, positive forward

l_y = transverse distance of lashing foundation from container corner fitting, in mm, positive to port

l_z = vertical separation of lashing foundation from container corner fitting, in mm, positive downwards

l_r = length of lashing rod or device, in mm

$= \sqrt{(l_x)^2 + (l_y)^2 + (l_z)^2}$

δ_{xi} = total longitudinal racking deflection of the top corner of container *i*, in mm

δ_{yi} = total transverse racking deflection of the corner of container *i*, in mm

δ_{zi} = total vertical displacement of the bottom corner of container *i*, in mm

θ_{Lr} = angle of the lashing rod *r* in the vertical plane

$$\theta_{Lr} = \tan^{-1}\left(\frac{l_z}{\sqrt{l_x^2 + l_y^2}}\right) \text{ degrees}$$

NOTE

θ_{Lr} is 90° when l_x and l_y are both zero

θ_{Lxyr} = angle of the lashing rod *r* in the xy plane (projection onto the horizontal plane)

$$= \tan^{-1}\left(\frac{l_y}{l_x}\right) \text{ degrees}$$

Use the atan2 function to maintain sign of angle. θ_{Lxyr} is 0° when l_x is positive and l_y is zero, θ_{Lxyr} is +90° when l_x is 0 and l_y is positive, θ_{Lxyr} is –90° when l_x is 0 and l_y is negative.

9.5.3 Where external support is provided by a buttress or shore, the load is to be transmitted between adjacent stacks by linkages in line with the support. The force in the transverse end wall members of the containers adjacent to the support is given by:

$F_b\left(\frac{2N-1}{2N}\right)$ kN and the force in the linkage to the adjacent container is $F_b\left(\frac{N-1}{N}\right)$ kN

where

F_b = calculated force in the buttress or shore, in kN

N = number of rows of containers supported by the buttress or shore.

9.6 Allowable forces on containers

9.6.1 For ISO containers, the securing arrangements are to be designed so that the forces on the containers do not exceed the values shown in Table 14.9.5. The maximum forces for ISO 1496-1: 1990 including Amendment Nos. 1, 2 and 3 containers are illustrated in Fig. 14.9.3. Proposals to carry out the lashing calculations for containers manufactured in accordance with ISO 1496-1:1990/Amendment No. 4, 2006 will be specially considered.

9.6.2 The allowable forces for containers of other dimensions, e.g., 24 ft, 48 ft and 53 ft, will be determined on the basis of the values in Table 14.9.5 and of the forces for which the container has been certified.

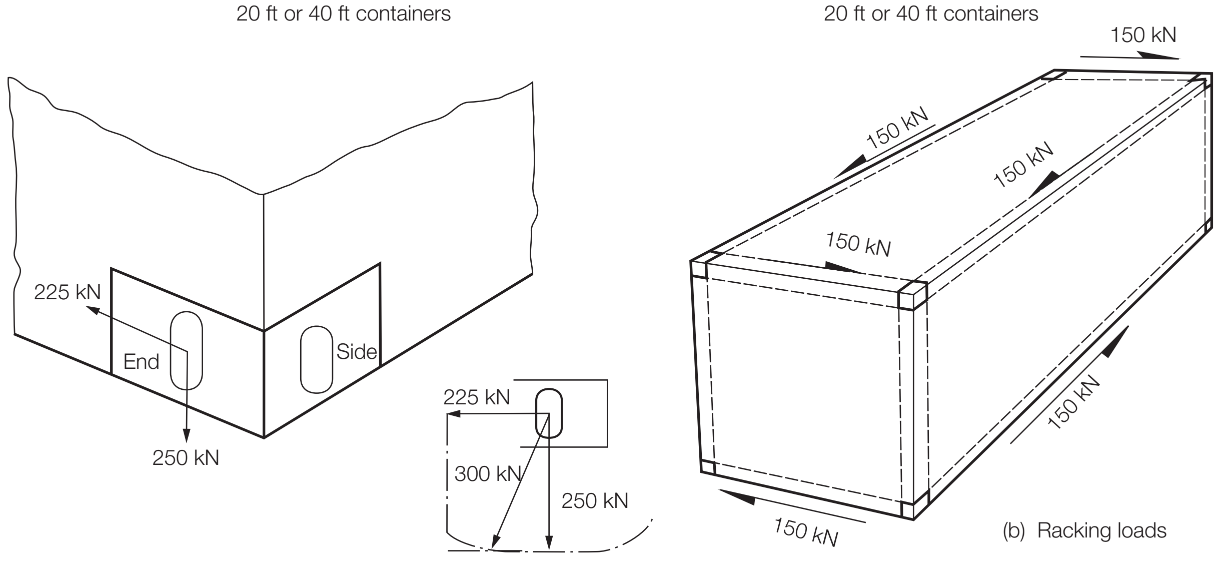
Table 14.9.5 Allowable forces on ISO containers

	ISO 1496-1:1990 including up to Amendment No. 3 20ft	40ft
	in kN	
Horizontal force from a container fitting acting parallel to the side face	150	150
Horizontal force from lashing on container fitting acting parallel to the end face, *see* Note 1	225	225
Vertical force from lashing on container fitting acting parallel to the end or side face, *see* Note 1	250	250
Racking force on container end	150	150
Racking force on container side	150	150
Vertical forces at each top corner, tension	250	250
Vertical forces at each bottom corner, tension	250	250
Vertical forces at each top corner post, compression	848	848
Vertical forces at each bottom corner casting of the lowest container in a stack, compression	848 + (1,8Rg/4) *see* Note 3	848 + (1,8Rg/4) *see* Note 3
Transverse forces acting at the level of and parallel to the top face, tension or compression, *see* Note 2	340	340
Transverse forces acting at the level of and parallel to the bottom face, tension or compression, see Note 2	500	500

NOTES

1. In no case is the resultant of the horizontal and the vertical forces to exceed the limiting values derived from Fig. 14.9.3(a).The horizontal and vertical forces are the maximum components of a diagonal force and are not to be used as the maximum load if horizontal or vertical lashings are employed.
2. Where a buttress supports the stack at an intermediate level, the total transverse force in the containers at the level is not to exceed the sum of the appropriate top and bottom forces.
3. The vertical compression force on the lower corner casting on the closed end of the lowest container may exceed 848 + (1,8Rg/4) kN, provided the following conditions are complied with:
   - (a) The vertical compression force acting on the lowest container from the container above does not exceed 848 kN.
   - (b) The horizontal racking force acting on the lowest container from the container above does not exceed 150 kN.
   - (c) The local ship side or hatch cover container foundation is designed and approved for the increased design compression force.
   - (d) The loose bottom container securing fittings should have a contact area fulfilling the requirements of 3.2.5.

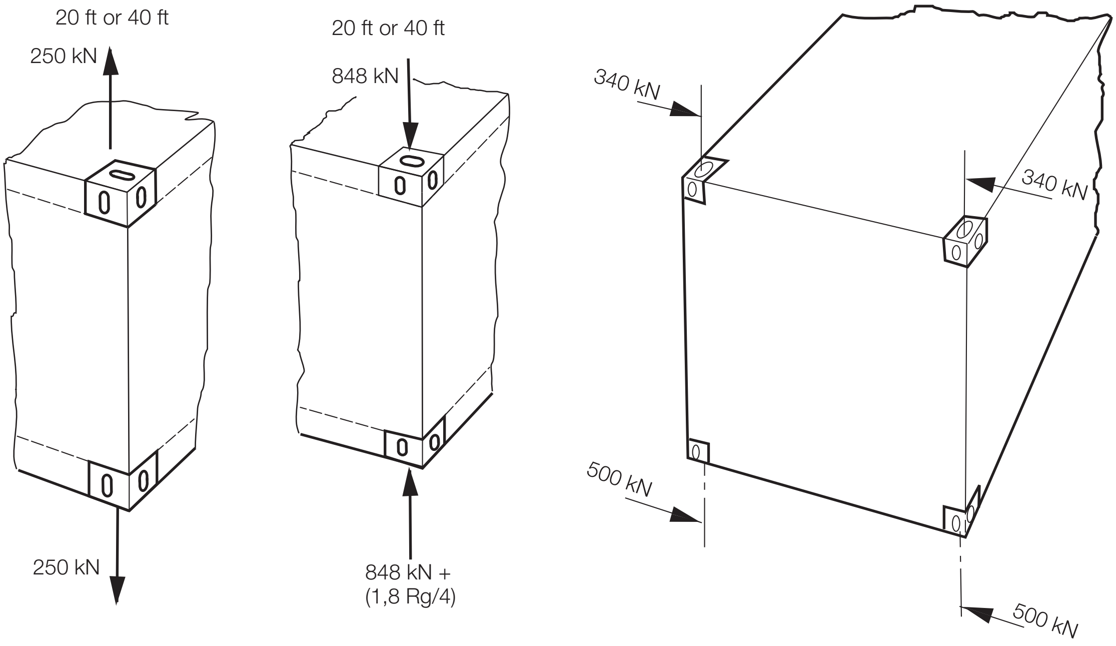
9.6.3 Where 45 ft containers in accordance with ISO 1496-1:1990/Amendment No. 4, 2006 are stowed on top of a 40 ft container, the corner post load of the top castings of the 45 ft container is not to exceed a compression force of 404 kN. Consideration should be given to the strength of the container bottom structure to withstand the forces transmitted. No lashings are to be applied to the ends of the 45 ft container if stowed on top of a 40 ft unit.



(b) Racking loads

(a) Corner casting lashing loads

20 ft (40 ft) container, tension or compression



(c) Vertical corner pull-out and compressive forces

(d) Transverse compressive forces

Fig. 14.9.3
Allowable forces for 20 ft or 40 ft containers constructed to ISO 1496-1:1990 including Amendment Nos. 1, 2 and 3

■ *Section 10*
Surveys

10.1 Initial Survey

10.1.1 The following requirements are mandatory for fixed fittings, including cell guides, if fitted, on all ships. For ships having a **CCSA** class notation the requirements are also applicable for loose fittings.

10.1.2 The Surveyor is to be satisfied that the materials, workmanship and arrangements are satisfactory and in accordance with the requirements and the approved plans. Any items found not to be in accordance with the requirements or the approved plans, or any material, workmanship or arrangements found to be unsatisfactory are to be rectified.

10.1.3 A Register or plan is to be kept on board and up to date, and is to be made available to the Surveyor upon request. The Register or plan is to contain sufficient details to enable all fittings to be identified, including:

- a simple sketch;
- the name of the item;
- the number supplied;
- the manufacturer's mark or code; and
- the safe working load with the corresponding breaking load.

10.1.4 For container securing arrangements, a suitable Container Stowage Arrangement Plan is to accompany the Register. Where containers of types other than ISO containers are proposed to be carried, their stowage locations are to be clearly indicated on the plan.

10.1.5 The Register and stowage plans, if applicable, may be included in the Cargo Securing Manual.

10.2 Periodical Surveys

10.2.1 For the requirements for Periodical Surveys, *see* Pt 1, Ch 3,2.2 and Pt 1, Ch 3,5.3.

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